U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

2023 Annual Merit Review

Vehicle Technologies Office

Results Report

May 2024

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Introduction

The 2023 U.S. Department of Energy (DOE), Office of Energy Efficiency and Renewable Energy's (EERE) Vehicle Technologies Office (VTO) Annual Merit Review (AMR) was held June 12-15, 2023, as a hybrid event with in-person and virtual attendance. The review encompassed work done by VTO: 257 individual activities were reviewed by 266 reviewers. Exactly 991 individual review responses were received for the VTO technical reviews.

The objective of the meeting was to review the accomplishments and plans for VTO over the previous 12 months, and provide an opportunity for industry, government, and academia to give inputs to DOE with a structured and formal methodology. The meeting also provided attendees with a virtual forum for interaction and technology information transfer.

The peer review process followed the guidelines of the Peer Review Guide developed by EERE. Each activity is reviewed every three years, at a minimum. However, VTO strives to have every activity reviewed every other year. The reviewers for the technical sessions were drawn from a wide variety of backgrounds, including current and former vehicle industry members, academia, government, and other expertise areas. Each reviewer was screened for conflicts of interest as prescribed by the Peer Review Guide.

Reviewers provided qualitative and quantitative feedback on VTO projects evaluated during the AMR. Qualitatively, reviewers offered written comments in response to a series of specific project evaluation questions. Quantitatively, reviewers provided numeric assessments for each of the same questions. These scores were organized and analyzed on both a project-level and subprogram-level basis. Tables summarizing the average numeric score for each question, with 4.0 being the highest possible score, by VTO subprogram portfolio are presented below.

Table I-1 – Average Project Scores, By VTO Research & Development Subprogram

VTO Subprogram	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
Battery R&D (BAT)	3.34	3.27	3.29	3.18	**3.28**
Electrification (ELT)	3.28	3.25	3.17	3.11	**3.23**
Decarbonization of Off-Road, Rail, Marine, and Aviation (DORMA)	3.36	3.32	3.32	3.29	**3.33**
Energy Efficient Mobility Systems (EEMS)	3.21	3.24	3.33	3.14	**3.23**
Materials Technology (MAT)	3.22	3.18	3.11	3.05	**3.17**
Vehicle Analysis (VAN)	3.42	3.59	3.26	3.48	**3.49**

Table I-2 – Average Project Scores, By VTO Technology Integration Subprogram

VTO Subprogram	Objectives	Approach	Accomplishments	Collaboration	Energy Equity/ Environmental Justice	Weighted Average
Technology Integration (TI)	3.51	3.47	3.23	3.42	3.21	**3.35**

Evaluation Criteria—Research & Development Subprograms

In the technical research and development (R&D) subprogram sessions, reviewers were asked to respond to a series of specific questions regarding the breadth, depth, and appropriateness of the VTO R&D activities. The technical questions are listed below, along with appropriate scoring metrics. These questions were used for all formal VTO R&D project reviews.

Question 1: Approach to performing the work—How would you rate the degree to which technical barriers are addressed? Is the project well designed, and is the timeline reasonably planned? (Scoring weight for overall average = 25%)

4.0=Outstanding. Sharply focused on critical barriers; difficult to improve significantly.

3.5=Excellent. Effective; contributes to overcoming most barriers.

3.0=Good. Generally effective but could be improved; contributes to overcoming some barriers.

2.5=Satisfactory. Has some weaknesses; contributes to overcoming some barriers.

2.0=Fair. Has significant weaknesses; may have some impact on overcoming barriers.

1.5=Poor. Minimally responsive to project objectives; unlikely to contribute to overcoming the barriers.

1.0=Unsatisfactory. Not responsive to project objectives; unlikely to contribute to overcoming the barriers.

Question 2: Technical Accomplishments and Progress—How would you rate the technical progress that has been made compared to the project plan? (Scoring weight for overall average = 50%)

4.0=Outstanding. Sharply focused on critical barriers; difficult to improve significantly.

3.5=Excellent. Effective; contributes to overcoming most barriers.

3.0=Good. Generally effective but could be improved; contributes to overcoming some barriers.

2.5=Satisfactory. Has some weaknesses; contributes to overcoming some barriers.

2.0=Fair. Has significant weaknesses; may have some impact on overcoming barriers.

1.5=Poor. Minimally responsive to project objectives; unlikely to contribute to overcoming the barriers.

1.0=Unsatisfactory. Not responsive to project objectives; unlikely to contribute to overcoming the barriers.

Question 3: Collaboration and Coordination Across Project Team— How would you rate the collaboration within the project team? Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed? (Scoring weight for overall average = 12.5%)

4.0=Outstanding. Close, appropriate collaboration with other institutions; partners are full participants and well-coordinated.

3.5=Excellent. Good collaboration; partners participate and are well-coordinated.

3.0=Good. Collaboration exists; partners are well-coordinated.

2.5=Satisfactory. Some collaboration exists; coordination between partners could be significantly improved.

2.0=Fair. A little collaboration exists; coordination between partners could be significantly improved.

1.5=Poor. Most work is done at the sponsoring organization with little outside collaboration; little or no apparent coordination with partners.

1.0=Unsatisfactory. No apparent coordination with partners.

Question 4: Proposed Future Research—How would you rate the proposed future research? Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets? (Scoring weight for overall average = 12.5%)

4.0=Outstanding. Purpose of future work and likelihood of achieving future work targets clearly stated.

3.5=Excellent. Effective; contributes to overcoming most barriers.

3.0=Good. Generally effective but could be improved; contributes to overcoming some barriers.

2.5=Satisfactory. Has some weaknesses; contributes to overcoming some barriers.

2.0=Fair. Has significant weaknesses; may have some impact on overcoming barriers.

1.5=Poor. Minimally responsive to project objectives; unlikely to contribute to overcoming the barriers.

1.0=Unsatisfactory. Not responsive to project objectives; unlikely to contribute to overcoming the barriers.

Question 5: Relevance—Is the project relevant? Does the project support the overall VTO subprogram objectives? (Did not factor into overall weighted average numeric score)

Yes

No.

Question 6: Resources—How would you rate the resources of the project? Are the resources sufficient for the project to achieve the stated milestones in a timely fashion? Did not factor into overall weighted average numeric score)

Excessive

Sufficient

Insufficient.

Evaluation Criteria—Technology Integration Subprogram

Reviewers for the Technology Integration (TI) technical session answered questions tailored to TI's 2023 AMR focus on improving fuel diversity, increasing local resiliency, and reducing greenhouse gas emissions. These technical questions are listed below, along with appropriate scoring metrics.

Question 1. Project Objectives— How would you rate this project's degree of support for the overall Technology Integration (TI) objectives of improving fuel diversity, increasing local resiliency, and reducing greenhouse gas emissions through increasing alternative fuel use and transportation efficiency? (Scoring weight for overall average = 20%)

4.0=Outstanding. Project Objectives are sharply focused on supporting DOE/VTO/TI objectives. The project has a direct and substantial impact upon addressing barriers; difficult to improve project objectives significantly.

3.5=Excellent. Project objectives are effective and substantially support DOE/VTO/TI objectives; project addresses a significant number of barriers; effectively contributes to program objectives.

3.0=Good. Project objectives are generally effective and support DOE/VTO/TI objectives but could be improved; project addresses some barriers; contributes to program objectives.

2.5=Satisfactory. Project objectives have some weaknesses and support DOE/VTO/TI objectives; project addresses some barriers; project may have some impact in achieving program objectives.

2.0=Fair. Project objectives have significant weaknesses and minimally support DOE/VTO/TI objectives; project addresses few barriers; project may have a small impact on achieving program objectives.

1.5=Poor. Project objectives are minimally responsive to DOE/VTO/TI objectives; project does not address barriers; project is unlikely to contribute materially to achieving program objectives.

1.0=Unsatisfactory. Project objectives are not responsive to DOE/VTO/TI objectives project fails to address any barriers; project is highly unlikely to contribute materially to achieving program objectives.

Question 2. Project Approach— How would you rate this project's approach for integrating advanced transportation technologies and practices to solve real-world challenges? (Scoring weight for overall average = 20%)

4.0=Outstanding. Project approach is sharply focused on achieving project objectives; difficult to improve project approach significantly.

3.5=Excellent. Effective; project approach contributes to achieving the majority of project Objectives.

3.0=Good. Generally effective but project approach could be improved; contributes to achieving some of the project objectives.

2.5=Satisfactory. Has some weaknesses; project approach contributes to achieving some project objectives.

2.0=Fair. Has significant weaknesses; project approach may have some impact on achieving project objectives.

1.5=Poor. Minimally responsive to project objectives; project approach is unlikely to contribute to achieving project objectives.

1.0=Unsatisfactory. Not responsive to project objectives; project approach is highly unlikely to contribute to achieving project objectives.

Question 3. Project Accomplishments and Progress— How would you rate the project's progress and significant accomplishments to date? (Scoring weight for overall average = 40%)

4.0=Outstanding. Project demonstrates significant accomplishments; strong progress toward achieving both project and VTO-TI objectives; difficult to improve progress significantly.

3.5=Excellent. Project demonstrates many accomplishments; very effective progress toward achieving overall project objectives and VTO-TI goals.

3.0=Good. Project accomplishments are generally effective; progress is on schedule to contribute to some project objectives and VTO-TI goals.

2.5=Satisfactory. Project has some accomplishments, but also displays some weaknesses; progress could be improved; contributes to some project objectives and VTO-TI goals.

2.0=Fair. Project has few accomplishments and demonstrates significant weaknesses; rate of progress is slow; minimal contribution to project objectives or VTO-TI goals.

1.5=Poor. Minimal demonstration of accomplishments; progress is significantly behind schedule; unlikely to contribute to project objectives or VTO-TI goals.

1.0=Unsatisfactory. Project demonstrates no accomplishments; limited or no demonstrated progress; not responsive to project objectives.

Question 4. Collaboration and Coordination Among Project Team— How would you rate the level of collaboration within the project team and the degree to which the project team has identified and leveraged the proper connections to achieve its project goals? (Scoring weight for overall average = 10%)

4.0=Outstanding. Sharply focused on collaboration among project team members; team is well-suited to effectively carry out the work of the project and have strong working relationships; no notable weaknesses.

3.5=Excellent. Effective; team members meaningfully contribute to carrying out the work of the project, are well-suited to effectively carry out the work and have excellent working relationships.

3.0=Good. Generally effective but could be improved; collaboration exists; team members are fairly well-suited to project work and have good working relationships.

2.5=Satisfactory. Has some weaknesses; collaboration among team members is satisfactory for carrying out the work of the project; project partnerships, team members and working relationships could be improved.

2.0=Fair. Has significant weaknesses; little collaboration exists and team lacks effective working relationships.

1.5=Poor. Minimally responsive; little collaboration exists and team lacks effective working relationships.

1.0=Unsatisfactory. Little or no apparent collaboration between team members; project team is lacking critical expertise to effectively carry out the work of the project.

Question 5. Energy Equity and Environmental Justice Project Contribution— How would you rate the contribution of this project to energy equity and environmental justice by ensuring the project benefits underserved and overburdened communities and does not cause increased burdens to these communities? (Scoring Weight for overall average = 10%)

4.0=Outstanding. Project maximizes the benefits to underserved and overburdened communities and incorporates affected communities in the planning and execution of the project.

3.5=Excellent. Project maximizes the benefits to underserved and overburdened communities and includes some collaboration with affected communities.

3.0=Good. Project will have significant benefits to underserved and overburdened communities.

2.5=Satisfactory. Project will have some benefits to underserved and overburdened communities.

2.0=Fair. Project does not benefit or burden underserved and overburdened communities.

1.5=Poor. Project will have some benefits to underserved and overburdened communities while also causing increased burdens to underserved and overburdened communities.

1.0=Unsatisfactory. Project has no benefits to underserved and overburdened communities while also causing increased burdens to underserved and overburdened communities.

Project Scoring

R&D Subprogram Projects

For R&D subprogram sessions, reviewers were asked to provide numeric scores (on a scale of 1.0-4.0 in one-half point increments, as indicated above) for Question 1 through Question 4 of each formally reviewed activity. For each reviewed project, the individual reviewer scores for Question 1 through Question 4 were averaged to provide information on the project's question-by-question scoring. Scores for each of these four criteria were weighted using the formula below to create a Weighted Average for each project. This allows a project's question-by-question and final overall scores to be meaningfully compared against another project:

Weighted Average* = [Question 1 Score x 0.25] + [Question 2 Score x 0.50] +

[Question 3 Score x 0.125] + [Question 4 Score x 0.125]

*R&D subprogram Questions 5 and 6 were not factored in the Weighted Average Score calculation because their scoring scales were incompatible with Questions 1 through 4.

Each reviewed activity has a corresponding bar chart representing that project's average scores for each of the four designated criteria. As demonstrated in Figure 1, a bullet and error line are included within the green bars representing the corresponding average and standard deviation of criteria scores for all of the reviewed projects in the same subprogram.

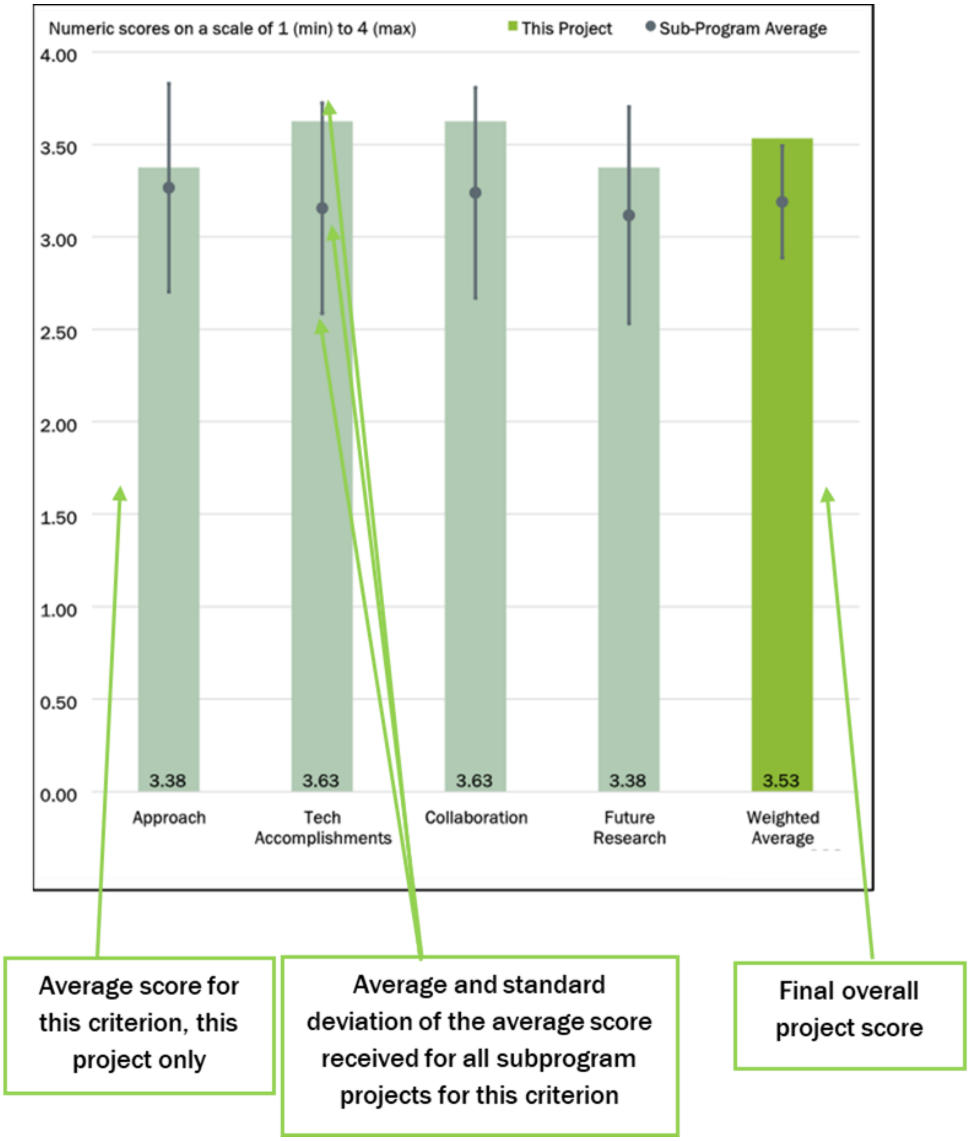

Figure 1. Sample Question 1 through Question 4 score averages, standard deviations, and overall Weighted Average for an R&D subprogram project

Reviewers were also asked to evaluate a given project's relevance and funding through Question 5 and Question 6, which were each scored on a different scale than Question 1 through Question 4. For the R&D subprogram sessions, while Question 1 through Question 4 were rated on a 1.0 to 4.0 scale in one-half point increments, Question 5 was rated on a yes or no scale, and Question 6 was rated on an excessive, sufficient, or insufficient scale. Consequently, Question 5 and Question 6 results were excluded from the Weighted Average calculation (as shown above) because the scoring scales are incompatible.

TI Subprogram Projects

For the TI subprogram session, reviewers were asked to provide numeric scores (on a scale of 1.0-4.0 in one-half point increments, as indicated above) for Question 1 through Question 5 of each formally reviewed activity. For each reviewed project, the individual reviewer scores for Question 1 through Question 5 were averaged to provide information on the project's question-by-question scoring. Scores for each of these five criteria were weighted using the formula below to create a Weighted Average for each project. This allows a project's question-by-question and final overall scores to be meaningfully compared against another project:

Weighted Average = [Question 1 Score x 0.20] + [Question 2 Score x 0.20] +

[Question 3 Score x 0.40] + [Question 4 Score x 0.10] + [Question 5 Score x 0.10]

Each reviewed TI activity has a corresponding bar chart representing that project's average scores for each of the five designated criteria. As demonstrated in Figure 2, a bullet and error line are included within the green bars representing the corresponding average and standard deviation of criteria scores for all of the reviewed projects in the same subprogram.

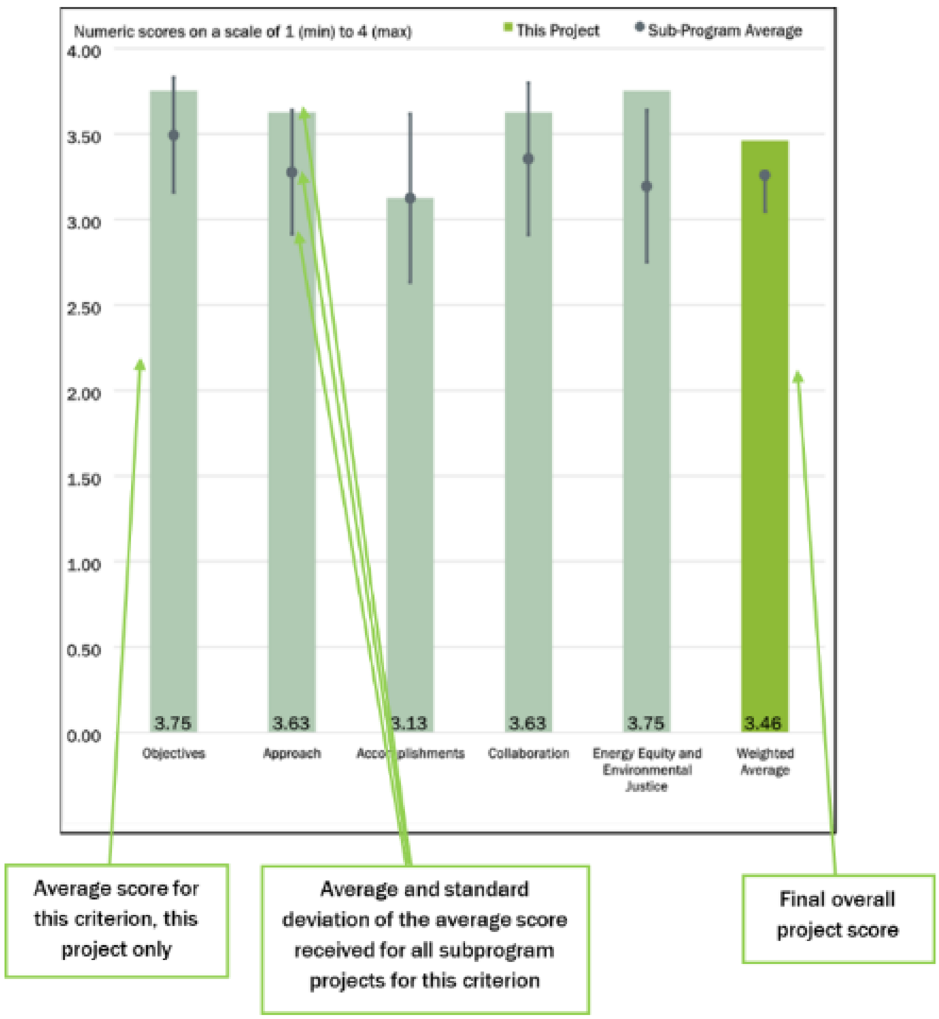

Figure 2. Sample Question 1 through Question 5 score averages, standard deviations, and overall Weighted Average for a TI subprogram project

Reviewer Responses

Text responses and numeric scores to the questions were submitted electronically through a web-based software application, PeerNet, operated by Oak Ridge Associated Universities (ORAU). Database outputs from this software application were analyzed and summarized to collate the multiple-choice, text comments, and numeric scoring responses and produce the summary report.

Responses to the questions are summarized in this report, with summaries of numeric scores for each technical session, as well as text and graphical summaries of the responses for each individual technical activity. For each project, the reviewer sample size is identified.

Each reviewed activity is identified by Presentation Number, followed by the Presentation Title, the Principal Investigator (PI), and the PI's organization. For each subprogram area, reviewed activities are ordered numerically by project number. Figure 3, below, provides an example project title.

Presentation Number: ELT197
Presentation Title: High Power and Dynamic Wireless Charging of Electric Vehicles
Principal Investigator: Veda Galigekere (Oak Ridge National Laboratory)

Figure 3. Sample project title with Presentation ID, Presentation Title, PI, and PI organization.

For each project, in addition to the PI, the presenter at the AMR is identified, along with the reviewer sample size. For some projects, the presenter at the AMR was a project team member rather than the PI.

Individual reviewer comments for each question are identified under the heading Reviewer 1, Reviewer 2, etc. Note that for each question the order of reviewer comments may be different; for example, for each specific project the reviewer identified as Reviewer 1 in the first question may not be Reviewer 1 in the second question, etc. Not all reviewers provided a response to each question for a given project.

The report is organized by technical subprogram area. Each technical area section includes a summary of that subprogram, a subprogram activities score summary table (and page numbers), project-specific reviewer evaluation comments with corresponding bar graphs, and a list of acronyms and abbreviations.

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1. Battery R&D

The Vehicle Technologies Office (VTO) supports research, development, demonstration, and deployment (RDD&D) of new, efficient, and clean mobility options that are affordable for all Americans. The office's investments leverage the unique capabilities and world-class expertise of the national laboratory system to develop new innovations in vehicle technologies, including: advanced battery technologies; advanced materials for lighter-weight vehicle structures and better powertrains; energy-efficient mobility technologies and systems (including automated and connected vehicles as well innovations in connected infrastructure for significant systems-level energy efficiency improvement); innovative powertrains to reduce greenhouse gas (GHG) and criteria emissions from hard to decarbonize off-road, maritime, rail, and aviation sectors; and technology integration that helps demonstrate and deploy new technology at the community level. In coordination with the other offices across the Office of Energy Efficiency and Renewable Energy (EERE) and the U.S. Department of Energy (DOE), VTO advances technologies that assure affordable, reliable mobility solutions for people and goods across all economic and social groups; enable and support competitiveness for industry and the economy/workforce; and address local air quality and use of water, land, and domestic resources.

The Batteries subprogram supports the decarbonization of transportation across all modes, serves to increase American advancement/manufacturing of battery technology, and creates good paying jobs with the free and fair chance to join a union and bargain collectively. The subprogram supports research with partners in academia, national laboratories, and industry covered under the Energy Storage Grand Challenge key priority and four distinct crosscuts including: Critical Materials, Grid Modernization, Advanced Manufacturing, and Energy Sector Cybersecurity.

The subprogram supports early-stage R&D of high-energy and high-power battery materials, cells, and battery development that can enable industry to significantly reduce the cost, weight, volume, and charge time of plug-in electric vehicle (PEV) batteries. This activity is organized into three sub-activities: advanced battery materials research, advanced battery cell R&D, and battery recycling R&D. Advanced battery materials research is coordinated with the Critical Minerals Initiative and includes: early-stage research of new lithium-ion (Li-ion) cathode, anode, and electrolyte materials (currently accounting for 50% to 70% of PEV battery cost) and the development of "beyond Li-ion" technologies, such as lithium (Li) metal anodes, solid-state electrolytes (SSE), and sulfur-based cathodes, that have the potential to significantly reduce weight, volume, and cost reduction of over 80% 2008 baseline, with a target of $60/kWh.

Advanced battery cell R&D includes early-stage R&D of new battery cell technology that contains new materials and electrodes that can reduce the overall battery cost, weight, and volume while improving energy, life, safety, and fast charging. Battery recycling R&D includes the development of innovative battery materials recycling and reuse technologies, and the Lithium-Ion Battery Recycling Prize, both of which aim to assure sustainability and domestic supplies of key battery materials and minerals.

Project Feedback

In this merit review activity, each reviewer was asked to respond to a series of questions, involving multiple-choice responses, expository responses where text comments were requested, and numeric score responses (on a scale of 1.0 to 4.0). In the pages that follow, the reviewer responses to each question for each project are summarized: the multiple choice and numeric score questions are presented in graph form for each project, and the expository text responses is summarized in paragraph form for each question. A table of the average numeric score for each question for each project is presented below.

Table 1-1 – Project Feedback

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
BAT028	Materials Benchmarking Activities for Cell Analysis, Modeling, and Prototyping (CAMP) Facility†	Wenquan Lu (Argonne National Laboratory)	1-8	3.60	3.30	3.70	3.40	3.44
BAT164	Advanced Processing Science for Novel Battery Electrode Architectures	Jianlin Li (Oak Ridge National Laboratory)	1-12	3.50	3.50	3.25	3.33	3.45
BAT167	Process Development and Scale-Up of Advanced Active Battery Materials	Ozge Kahvecioglu (Argonne National Laboratory)	1-17	3.50	3.50	3.88	3.50	3.55
BAT168	Process Development and Scale-Up of Critical Battery Materials - Continuous Flow-Produced Materials	Krzysztof Pupek (Argonne National Laboratory)	1-21	3.42	3.33	3.75	3.42	3.42
BAT226	Probing Interfacial Processes Controlled Electrode Stability in Rechargeable Batteries†	Chongmin Wang (Pacific Northwest National Laboratory)	1-26	3.50	3.25	3.75	3.38	3.39
BAT230	Nanostructured Design of Sulfur Cathode for High-Energy Lithium-Sulfur Batteries†	Yi Cui (Stanford University / SLAC National Accelerator Laboratory)	1-30	3.50	3.63	3.50	3.50	3.56
BAT232	High Energy Density Electrodes via Modifications to the Inactive Components and Processing Conditions	Vincent Battaglia (Lawrence Berkeley National Laboratory)	1-34	3.25	3.33	3.25	3.08	3.27
BAT280	Novel Chemistry: Lithium-Selenium and Selenium-Sulfur Couple†	Khalil Amine (Argonne National Laboratory)	1-39	3.50	3.38	3.13	3.38	3.38

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
BAT285	Investigation of Sulfur Reaction Mechanisms†	Deyang Qu (University of Wisconsin at Milwaukee)	1-44	3.50	3.50	3.30	3.40	3.46
BAT315	Process R&D for Droplet-Produced Powdered Materials	Joe Libera (Argonne National Laboratory)	1-50	3.10	3.00	3.00	3.00	3.03
BAT360	Scale-up, Optimization and Characterization of High-nickel Cathodes†	Arumugam Manthiram (University of Texas at Austin)	1-55	3.38	3.25	2.75	3.00	3.19
BAT362	High-Capacity S Cathode Materials†	Prashant Kumta (University of Pittsburgh)	1-59	3.50	3.30	3.50	3.20	3.36
BAT367	Multiscale Characterization Studies of Li Metal Batteries†	Peter Khalifah (Brookhaven National Laboratory)	1-63	3.50	3.50	3.70	3.30	3.50
BAT368	Full Cell Diagnostics and Validation to Achieving High Cycle Life†	Eric Dufek (Idaho National Laboratory)	1-68	3.14	3.00	3.29	2.64	3.03
BAT377	ReCell–Overview and Update	Jeffrey Spangenberger (Argonne National Laboratory)	1-74	3.00	3.00	3.38	3.13	3.06
BAT386	eXtreme Fast Charge Cell Evaluation of Lithium-Ion Batteries (XCEL)–Overview and Progress Update	Venkat Srinivasan (Argonne National Laboratory)	1-79	3.50	3.83	3.83	3.67	3.73
BAT423	Development of New Electrolytes for Lithium-Sulfur Batteries†	Gao Liu (Lawrence Berkeley National Laboratory)	1-82	3.50	3.40	3.50	3.40	3.44
BAT427	In Situ and Operando Thermal Diagnostics of Buried Interfaces in Beyond Lithium-Ion Cells†	Sumajeet Kaur (Lawrence Berkeley National Laboratory)	1-87	3.00	3.00	2.00	2.83	2.85
BAT429	Electrolytes and Interfaces for Stable High Energy Sodium-Ion Batteries†	Jason Zhang (Pacific Northwest National Laboratory)	1-90	3.38	3.38	3.25	3.38	3.36

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
BAT456	eXtreme Fast Charge Electrode and Cell Design Thrust	Andrew Jansen (Argonne National Laboratory)	1-94	3.50	3.33	3.83	3.33	3.44
BAT463	eXtreme Fast Charge Electrochemical and Thermal Performance Thrust	Eric Dufek (Idaho National Laboratory)	1-97	3.67	3.50	3.50	3.50	3.54
BAT470	Process R&D Using Supercritical Fluid Reactors	Youngho Shin (Argonne National Laboratory)	1-100	3.33	3.42	3.42	3.33	3.39
BAT475	Towards Solventless Processing of Thick Electron-Beam (EB) Cured Lithium-Ion Battery Cathodes	Zhijia Du (Oak Ridge National Laboratory)	1-106	3.50	3.50	3.42	3.25	3.46
BAT524	Advanced Electrolytes for Li Metal Batteries†	Chunsheng Wang (University of Maryland)	1-112	3.63	3.50	3.50	3.50	3.53
BAT528	Structurally and Electrochemically Stabilized Silicon-rich Anodes for Electric Vehicle Applications†	John Thorne (Enovix)	1-116	3.17	3.17	3.17	3.17	3.17
BAT529	Rationally Designed Lithium-Ion Batteries Towards Displacing Internal Combustion Engines†	Rick Costantino (Group 14 Technologies)	1-119	3.67	3.33	3.50	2.83	3.38
BAT531	Solid State Lithium-ion Batteries Using Silicon Composite Anodes†	Pu Zhang (Solid Power Battery)	1-122	3.17	3.00	2.67	3.00	3.00
BAT532	Electrolytes with Lithium-ion Batteries with Micro-sized Silicon Anodes†	Chunsheng Wang (University of Maryland)	1-125	3.13	2.88	3.38	2.75	2.98
BAT533	Fluorinated Local High Concentration Electrolytes Enabling High Energy Density Silicon Anodes†	Amy Marschilok (Stony Brook University)	1-129	3.00	3.17	3.17	2.83	3.08
BAT534	Devising mechanically compliant and chemically stable synthetic solid-electrolyte interphases on silicon†	Pierre Yao (University of Delaware)	1-132	3.17	2.83	3.17	2.83	2.96

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
BAT544	Machine Learning for Accelerated Life Prediction and Cell Design	Eric Dufek (Idaho National Laboratory)	1-135	3.63	3.50	3.63	3.50	3.55
BAT546	Scaling-Up and Roll-to-Roll Processing of Highly Conductive Sulfide Solid-State Electrolytes	Dongping Lu (Pacific Northwest National Laboratory)	1-139	3.10	3.30	3.30	2.70	3.18
BAT547	Continuous high yield production of defect-free, ultrathin sulfide glass electrolytes for next generation solid state lithium metal batteries	Tim Fister (Argonne National Laboratory)	1-143	3.40	3.30	3.30	3.30	3.33
BAT548	Scale-Up of Novel Li-Conducting Halide Solid State Battery Electrolyte	Mike Tucker (Lawrence Berkeley National Laboratory)	1-147	3.50	3.40	3.30	3.10	3.38
BAT571	ReCell Center-Direct Recycling of Materials	Jessica Durham Macholz (Argonne National Laboratory)	1-152	3.25	3.13	2.88	2.75	3.08
BAT572	ReCell Center-Advanced Resource Recovery	Yaocai Bai (ORNL)	1-156	2.88	3.00	2.75	2.88	2.92
BAT573	ReCell Center-Design for Sustainability	Andrew Colclasure (NREL)	1-160	2.75	2.75	2.50	2.75	2.72
BAT574	ReCell Center-Modeling and Analysis	Allison Bennett Irion (Argonne National Laboratory)	1-164	3.38	3.38	3.75	3.25	3.41
BAT575	eXtreme Fast Charge Electrolyte Development Thrust	Bryan McCloskey (Lawrence Berkeley National Laboratory)	1-168	3.67	3.67	3.67	3.50	3.65
BAT576	Solid State Batteries with Long Cycle Life and High Energy Density	Haegyum Kim (Lawrence Berkeley National Laboratory)	1-171	3.38	3.25	3.38	3.38	3.31
BAT577	Low-Pressure All-Solid State Cells	Tony Burrell (National Renewable Energy Laboratory)	1-175	3.50	3.17	3.67	3.33	3.33

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
BAT578	Stable Solid-State Electrolyte and Interface for High-Energy Density Lithium-Sulfur Battery	Dongping Lu (Pacific Northwest National Laboratory)	1-178	3.60	3.70	3.50	3.40	3.61
BAT579	Multifunctional Gradient Coatings for Scalable High-Energy Density Sulfide-Based Solid-State Batteries	Justin Connell (Argonne National Laboratory)	1-183	3.25	3.38	3.50	2.75	3.28
BAT580	Thick Selenium-Sulfur Cathode Supported Ultra-thin Sulfide Electrolytes for High-Energy All-Solid-State Batteries	Guiliang Xu (Argonne National Laboratory)	1-187	2.80	2.90	2.80	3.00	2.88
BAT581	Precision Control of the Lithium Surface for Solid-State Batteries	Andrew Westover (Oak Ridge National Laboratory)	1-192	3.20	3.00	3.00	3.20	3.08
BAT582	Inorganic-Polymer Composite Electrolytes with Architecture Design for Lithium Metal Solid-State Batteries	Enyuan Hu (Brookhaven National Laboratory)	1-196	3.00	2.75	2.88	2.88	2.84
BAT583	Development of All-Solid-State Battery Using Anti-Perovskite Electrolyte	Zonghai Chen (Argonne National Laboratory)	1-201	3.30	3.30	2.90	3.20	3.24
BAT584	Integrated Atomic-, Meso-, and Micro-Scale Diagnostics of Solid-State Batteries†	William Chueh (Stanford University/ SLAC National Accelerator Laboratory)	1-206	3.50	3.30	3.00	3.50	3.34
BAT585	Anode-Free Lithium Batteries†	Jason Zhang (Pacific Northwest National Laboratory)	1-211	3.00	2.88	3.00	3.25	2.97
BAT586	Earth-abundant Cathode Active Materials for Li-Ion Batteries: Cathode Design and Synthesis†	Jason Croy (Argonne National Laboratory)	1-216	3.20	3.10	3.20	3.00	3.13
BAT588	Earth-abundant Cathode Active Materials for Li-Ion Batteries: System Analysis†	Daniel Abraham (Argonne National Laboratory)	1-221	3.25	3.38	3.38	3.13	3.31
BAT589	Cation-disordered Cathode Materials (DRX+) - Synthesis, Scale-up and Cell Testing†	Guoying Chen (Lawrence Berkeley National Laboratory)	1-225	3.67	3.58	3.33	3.50	3.56

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
BAT592	Advanced Anode Manufacturing Through Ultra-Thin Li Deposition	Subramanya Herle (Applied Materials, Inc.)	1-230	3.50	3.38	3.88	3.38	3.47
BAT593	Strategies to Enable Lean Electrolytes for High Loading and Stable Lithium-Sulfur Pouch†	Shirley Meng (University of California at San Diego)	1-234	3.50	3.13	3.50	3.25	3.28
BAT594	New Engineering Concepts to High Energy Density Li-S Batteries†	Prashant Kumta (University of Pittsburgh)	1-238	3.00	2.88	2.38	2.88	2.84
BAT595	Development of Li-S Battery Cells with High Energy Density and Long Cycling Life†	Donghai Wang (Penn State University)	1-242	3.50	3.50	3.10	3.30	3.43
BAT596	Development of a High-Rate Li-Air Battery using a Gaseous CO_2 Reactant†	Amin Salehi-Khojin (University of Illinois at Chicago)	1-246	3.50	3.50	3.33	3.00	3.42
Overall Average				**3.34**	**3.27**	**3.29**	**3.18**	**3.28**

† Denotes a poster presentation.

Presentation Number: BAT028
Presentation Title: Materials Benchmarking Activities for Cell Analysis, Modeling, and Prototyping (CAMP) Facility
Principal Investigator: Wenquan Lu (Argonne National Laboratory)

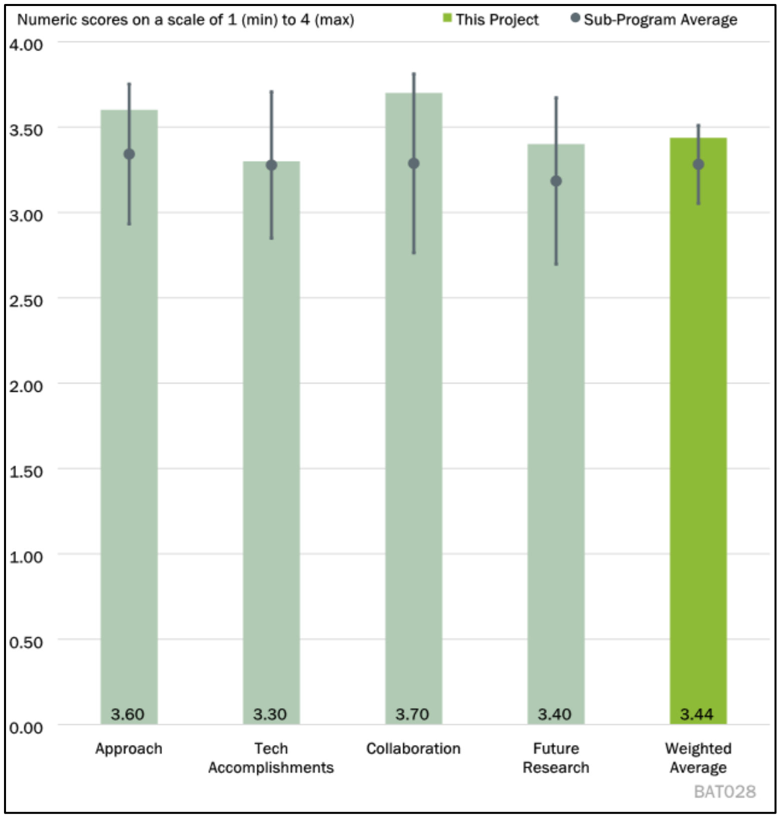

Figure 1-1 - Presentation Number: BAT028 Presentation Title: Materials Benchmarking Activities for Cell Analysis, Modeling, and Prototyping (CAMP) Facility Principal Investigator: Wenquan Lu (Argonne National Laboratory)

Presenter

Wenquan Lu, Argonne National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer noted that the project addressed one of the two technical barriers, specifically focusing on high-energy active materials’ identification and evaluation in coin cells. These materials included SSE, modified NMC523, SiO, and carbon nanotube (CNT) conductive agent. The project failed to elucidate how these efforts would address the barrier of creating sustainable electric vehicle (EV) batteries that meet or exceed the DOE/U.S. Advanced Battery Consortium (USABC) goals. However, from email correspondence with the principal investigator (PI), it was evident that they understood and had plans to test in full pouch cells, projecting performance for larger EV batteries.

Reviewer 2:

The reviewer observed that the project’s aim was to provide benchmarking services for battery material developers using a standard protocol with 2032 coin cells. Although this facility is vital for battery R&D programs, it presents no significant technical challenges. Electrochemical tests on battery cells are a common practice in the battery community. The team appeared to have undertaken activities beyond just benchmarking, as evidenced by the delayed milestone mentioning the coating of a thin layer of ceramic. The reviewer noted the absence of a defined timeline beyond March 2023.

Reviewer 3:

The reviewer acknowledged that the 2022 timeline was met, but delays were observed for the thin-film milestone set for early 2023. The SSEs polyethylene glycol diacrylate (PEGDA) and lithium lanthanum zirconate (LLZO), were relevant due to their elasticity against volume changes and high stability, respectively. Various electrolytes were studied, but performance testing in full EV cells was not conducted. The reviewer emphasized the need for high-capacity cathodes made from abundant crustal materials to reduce costs. NCM523, presented as an option to reduce Ni and Co usage, was highlighted. The reviewer also commended the PI's efforts to enhance cyclability, concluding that the technical barriers were addressed in a well-structured project with a feasible schedule.

Reviewer 4:

The reviewer found the technical barriers clearly defined and addressed. However, they wished the third task on the milestones slide (Slide 4) had an estimated completion time instead of merely being labeled as "Delayed."

Reviewer 5:

The research concentrated on active and additive materials, including additives for solid polymer electrolyte (SPE), nickel manganese cobalt (NMC) coating with Al_2O_3, SiO annealing, and carbon additives in the cathode mix. The reviewer pointed out these activities were geared toward meeting the cost and performance goals set by the DOE/USBAC.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer stated the annual milestone experienced delays due to supply chain interruptions caused by COVID-19.

Reviewer 2:

The project's objective was to identify and evaluate cell chemistries, and the technical accomplishments centered around SPE, NCM523 surface modification, SiO anode heat treatment, and electrode conductivity improvement using CNT. The reviewer confirmed these activities were aligned with the project's objectives, covering recent developments in cathodes, anodes, and electrolytes.

Reviewer 3:

Two out of three milestones were met, with one being delayed, according to the reviewer.

Reviewer 4:

The reviewer praised the work, noting that various materials were synthesized, characterized, and tested at the CAMP facility. They recommended mentioning if all five studied materials were initially provided by material developers and strongly advised testing using a single-layer pouch cell, skipping coin cell tests.

Reviewer 5:

The reviewer found the research progress consistent with the project plan, with notable achievements. Despite a delay caused by supply chain disruptions, the balance between research and validation was tipped more towards the former. The reviewer suggested a more balanced approach for future endeavors.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer deemed collaboration within the project as outstanding. While extensive collaborations existed both internally at Argonne National Laboratory (ANL) and externally with various industrial companies and universities, the reviewer felt that the individual contributions of the institutes remained unspecified.

Reviewer 2:

The reviewer recommended naming collaborators in the technical accomplishments section.

Reviewer 3:

The reviewer saw that while the project had numerous partners from national laboratories, universities, and industries, specific contributions from these entities were not clearly delineated.

Reviewer 4:

The reviewer remarked that it is great to see that collaboration has been extended not only to multiple national laboratories but also to many universities and most importantly to many industrial material, equipment, and cell developers.

Reviewer 5:

The reviewer commented that the research work was well coordinated; however, the roles and contributions from different collaborators are not well specified.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer noted that the project clearly defined a purpose for its future work and deemed the plan achievable.

Reviewer 2:

The reviewer stated that one persistent challenge was the identification of high-energy active materials. The primary obstacle was identified as accessing these advanced active materials. As the project's main focus was on benchmarking rather than R&D, this hurdle was not viewed as a technical challenge but rather as a public relations or outreach mission. The reviewer also highlighted that since future activities largely relied on inputs from research institutes and industry developers, it was not practical for the project team to define future endeavors internally.

Reviewer 3:

The reviewer acknowledged that while the areas for continued research were clearly identified, a more in-depth definition of the active materials, specifically the cathode and anode, was necessary. They also pointed out that the rationale for persisting with the research on the selected topic was not explicitly mentioned.

Reviewer 4:

In terms of the proposed future work, the reviewer found it to be very well articulated in alignment with the project's objective. They offered a suggestion: to study the higher nickel cathode, specifically NCM 811, and expressed curiosity about the selection of NCM532 for the project.

Reviewer 5:

The reviewer confirmed that the project had a distinct direction for future work, detailing each task. They believed that the upcoming research was poised to successfully meet its goals.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer observed that the project persistently emphasized screening and evaluating new battery materials. This effort aimed to augment the CAMP electrode library and bolster the CAMP facility's prototyping capabilities, aligning with the broader goals of the VTO subprogram.

Reviewer 2:

The reviewer found the project's objectives to be in sync with the VTO program's expectations.

Reviewer 3:

The reviewer noted that the project extended its support to various domains, including analysis, batteries, energy-efficient mobility systems, and materials. Emphasis was placed on the evaluation of electrolytes in full cells and enhancing cathode structures to optimize battery cycle life.

Reviewer 4:

The reviewer identified the project as supportive of the VTO Batteries subprogram within the VTO's objectives.

Reviewer 5:

The reviewer underscored the project's dedication to benchmarking and fostering a deeper comprehension of the active and additive materials. The reviewer emphasized that such endeavors undoubtedly fortify the CAMP facility's role in prototyping cells and nurturing the development of its electrode library, which serves the overarching VTO subprogram objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer believed that the project had adequate resources to achieve the designated milestones punctually. They suggested a possible reorientation: if the project could direct more efforts towards screening and evaluating battery materials in larger cells, specifically 1–2 Ah cells, instead of relying solely on coin cells, it might offer more pertinent outcomes. These results, the reviewer felt, would better align with the VTO's objectives for EV battery development. While coin cells offer a rapid means for material screening, it is beneficial to validate performance in larger pouch cells.

Reviewer 2:

The reviewer noted that while resources were deemed sufficient for the task at hand, the report did not provide clarity on future milestones.

Reviewer 3:

Regarding the CAMP facility, the reviewer highlighted that its collaboration with various partners augmented its capability to contribute to and bolster the final, scalable products across industries.

Reviewer 4:

The reviewer stated that the project's resources were aptly allocated and were sufficient.

Reviewer 5:

While resources were generally seen as ample to meet the outlined milestones, the reviewer pointed out the potential for delays, stemming from supply chain disruptions.

Presentation Number: BAT164
Presentation Title: Advanced Processing Science for Novel Battery Electrode Architectures
Principal Investigator: Jianlin Li (Oak Ridge National Laboratory)

Presenter

Jianlin Li, Oak Ridge National Laboratory

Reviewer Sample Size

A total of six reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

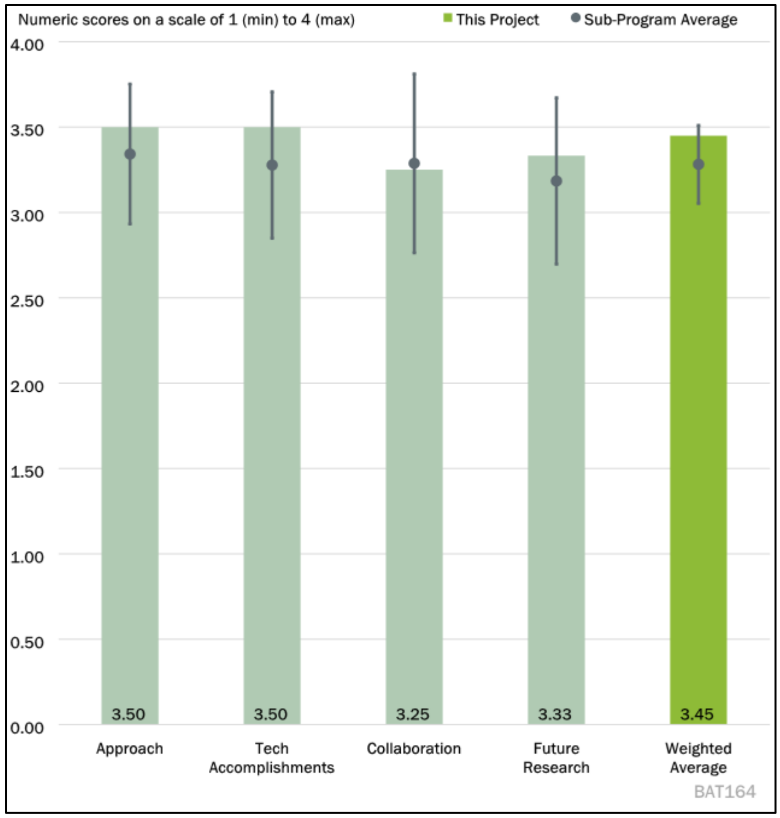

Figure 1-2 - Presentation Number: BAT164 Presentation Title: Advanced Processing Science for Novel Battery Electrode Architectures Principal Investigator: Jianlin Li (Oak Ridge National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer noted that the project primarily proposed two significant tasks: demonstrating a two-layer thick cathode and demonstrating a working solid-state battery (SSB). The task to fabricate a two-layer thick cathode aimed to improve energy and power density, and it was both justified and well-designed.

Reviewer 2:

The reviewer observed that the project aimed to increase electrode loading by creating a thick electrode. The primary technical barrier addressed was the compromise between energy density and power density. The two-layer electrode design, which included an energy layer and a power layer, was compelling. The freeze casting technique, which was anticipated to enhance Li diffusion rates, was of particular interest. The PI was advised to examine the porosity, specifically the pore distribution, of both layers to further refine the electrode creation process.

Reviewer 3:

The reviewer found the project to be highly challenging. During the review period, the team appeared to have more successfully tackled issues related to understanding cathode processing than they had with optimizing and addressing cost issues.

Reviewer 4:

The reviewer believed that the approach presented was logical. The objectives for future work into 2024 were clear. However, the target completion date of Sept. 30, 2024 (as mentioned on Slide 2) seemed ambitious, and the project might require additional time and effort.

Reviewer 5:

The reviewer noted that the work directly addressed the problems highlighted, such as the cracking of thick coatings with a water solvent and the long cycle-life of SSBs.

Reviewer 6:

The reviewer commented that the research work was conducted closely aligned with the stated barriers. From their observation, the study appeared to be well-planned and was progressing smoothly.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer observed that the two-layer cathode had effectively showcased improved rate performance. This task was completed punctually. The challenge associated with making the lower layer denser was aptly identified. Additionally, the conundrum of achieving both high porosity and high electrical conductivity was also accurately identified and communicated. While a working SSB was presented with several challenges highlighted, the reason for the bottom layer still being fabricated through a conventional process—instead of the freeze casting method—remained ambiguous. Was this a result of the interface between the two layers or because the bottom layer made by the freeze casting method could not be as dense as the conventionally produced ones? A study delving into this would benefit the understanding or enhancement of the two-layer manufacturing process.

Reviewer 2:

The reviewer mentioned that the electrode's performance was tested in different systems, including a solid-state one. An impressive performance from a high loading electrode was displayed. The PI was advised to systematically probe the impact of various process parameters on electrode performance.

Reviewer 3:

The reviewer noted that the experiments were well-conceived to address vital questions, yet there remained numerous unresolved issues. The concept of the two-layer porosity electrode intrigued the reviewer, but the specifics, like how Li transport would function, especially in cases of lower porosity, were vague. Further examination of this problem was deemed essential. While rate performance and cycle life improvements were commendable, the experiment testing ionic conductance lacked clarity. Analyses concerning different salts (lithium bis(fluorosulfonyl)imide [LiFSI] vs. lithium bis(trifluoromethanesulfonyl)imide [LiTFSI]) appeared to be of limited value. Given the multitude of variables, it was challenging to pinpoint the most pivotal ones. Mentions of nanoscale domains and solid-electrolyte-interphase (SEI) composition were present, but their connection to cell performance or processing specifics was not established.

Reviewer 4:

The reviewer found the findings concerning cluster domain formation with LiFSI vs. LiTFSI to be engaging. More extensive details on freeze casting process parameters would have been beneficial. Beyond solids content, were there other variables influencing pore structure, such as freezing rate, particle size, or solvent composition? Even if altering these parameters was not feasible, and presentation time was restricted, sharing more insights about the freeze casting process would have provided a more comprehensive grasp.

Reviewer 5:

The reviewer acknowledged the team's clear progress in slurry coatings using the freeze tape casting process and their significant headway regarding cell cycle life with the LiTFSI solid-state polymer electrolyte. However, the cathode-specific capacity was on the lower side (100 mAh/g as opposed to the approximately 170 mAh/g of traditional NMC622). Moreover, evident challenges persisted, especially concerning the SSE, like the high current density Li stripping issue.

Reviewer 6:

The reviewer commented that all preliminary results appeared encouraging. This included the aqueous-based ink and coating, the electrode architecture design and preparation, and its performance in solid-state cells. Concerns potentially impacting future industrialization were also assessed and addressed.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer noted that the collaboration concentrated on material aspects, particularly on the electrolyte, cathode synthesis, and binder selection. The findings were disseminated to battery manufacturers for the potential integration of this technology.

Reviewer 2:

The reviewer highlighted that the PI collaborated with a diverse group, including those from material manufacturing, equipment manufacturing, universities, and national laboratories. The PI was encouraged to showcase the results of these collaborations and their subsequent impact.

Reviewer 3:

The reviewer mentioned that a range of collaborations had been initiated with both academia and industry.

Reviewer 4:

From the reviewer's observation, there seemed to be a multitude of partnerships: collaborations with other laboratories and universities for analytical endeavors, with commercial material suppliers for diverse materials, and with equipment suppliers, among others. The transition of these processes to a more scalable and continuous operation was of interest, especially given the current assumption that many processes were executed in batches.

Reviewer 5:

While the reviewer recognized the existing collaborations associated with certain tasks, they expressed a desire for a more detailed explanation of the interactions and dynamics between the partners.

Reviewer 6:

The reviewer commended the well-orchestrated research efforts across universities, national laboratories, and material suppliers. Although some findings awaited further validation from battery manufacturers and extended evaluations in end products, the PI's proactive approach in sharing the results with leading battery manufacturers was lauded.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer recognized the absence of an established fabrication method for SSBs, signaling a distinct avenue for upcoming research. However, there was ambiguity regarding the chosen fabrication technique for future studies and how this research would address the identified fabrication challenges.

Reviewer 2:

The reviewer observed that the planned future research aligned with the project's objectives, aiming to surmount barriers. Specifically, the assessment of the electrode/SSE interface could enhance comprehension of SSE batteries. The PI was urged to undertake more comprehensive cell testing.

Reviewer 3:

The reviewer deemed the future plans to be logical and in harmony with the outlined research.

Reviewer 4:

The reviewer conveyed enthusiasm for the work in progress, noting that the steps for the remainder of 2023 were well-defined. However, there was a concern about the projected end date of Sept. 30, 2024, as presented on Slide 2. The objectives detailed on Slide 17 for Fiscal Year (FY) 2024 seemed ambitious, hinting at significant forthcoming work that might necessitate considerable effort.

Reviewer 5:

The reviewer acknowledged that the team had pinpointed several tasks addressing the program's deficiencies and had identified the primary technical hurdles that remained to the program's success.

Reviewer 6:

The reviewer commended the project for its lucid definition of both near-term and mid-term research priorities and objectives. The alignment of these with the highlighted barriers was appreciated. The PI's emphasis on future commercialization activities was notably lauded.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer noted that the project aimed to fabricate thick electrodes with distinct architectures. This direction aligned with the VTO objectives of achieving high-performing EV batteries and cells. By addressing the project's goal, there was potential to enhance the charge rate performance, while adhering to specific energy density requirements and taking into consideration fabrication method constraints. A key observation was that augmenting the thickness, or areal capacity, of the electrodes could boost a battery cell's energy. This enhancement came from amplifying the quantity of active material and concurrently reducing the proportional cost of other inactive components.

Reviewer 2:

The reviewer remarked that the project bolstered the overarching VTO objectives. This was achieved by exploring ways to augment the energy density of SSBs, particularly by utilizing a high loading electrode.

Reviewer 3:

For the reviewer, the project's relevance was evident in its commitment to forging low-cost, thick cathodes that deliver commendable battery performance. Such an endeavor was deemed crucial for the VTO's mission.

Reviewer 4:

The reviewer recognized the project's clear orientation towards propelling battery technology forward. This advancement spanned both innovative architectures, like controlled cathode pore structure and electrolyte morphology, and novel manufacturing methodologies such as freeze tape casting. The project's endeavors were viewed as invigorating.

Reviewer 5:

The reviewer acknowledged the program's pertinence in advancing battery research. The focus was on crafting high-energy density/medium power NMC battery systems and furthering exploration into SSBs, which represented a future trajectory for Li-ion batteries (LIBs).

Reviewer 6:

The reviewer emphasized that the project supported the VTO subprogram's goals. These encompassed reducing battery-related expenses while simultaneously enhancing cell energy and power density.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer observed that the team was equipped with a pilot-scale coater, a dry room, and pouch cell evaluation facilities at Oak Ridge National Laboratory (ORNL) to realize the stipulated objectives.

Reviewer 2:

The PI and their collaborators, according to the reviewer, possessed adequate resources to carry out the proposed research.

Reviewer 3:

The reviewer stated that the resources were satisfactory.

Reviewer 4:

Looking ahead, the reviewer noted that if the project exhibited potential in 2024, there might be a need for additional resources to upscale the technology.

Reviewer 5:

The reviewer acknowledged the adequacy of the program's resources and collaborations. The team seemed well-positioned to attain their objectives. The achievement of key milestones, especially pertaining to the solid-state segment, would depend on the team's technical prowess and cooperative endeavors.

Reviewer 6:

The reviewer emphasized that the researchers had ample resources at their disposal to meet the project's set milestones.

Presentation Number: BAT167
Presentation Title: Process Development and Scale-Up of Advanced Active Battery Materials
Principal Investigator: Ozge Kahvecioglu (Argonne National Laboratory)

Presenter

Ozge Kahvecioglu, Argonne National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

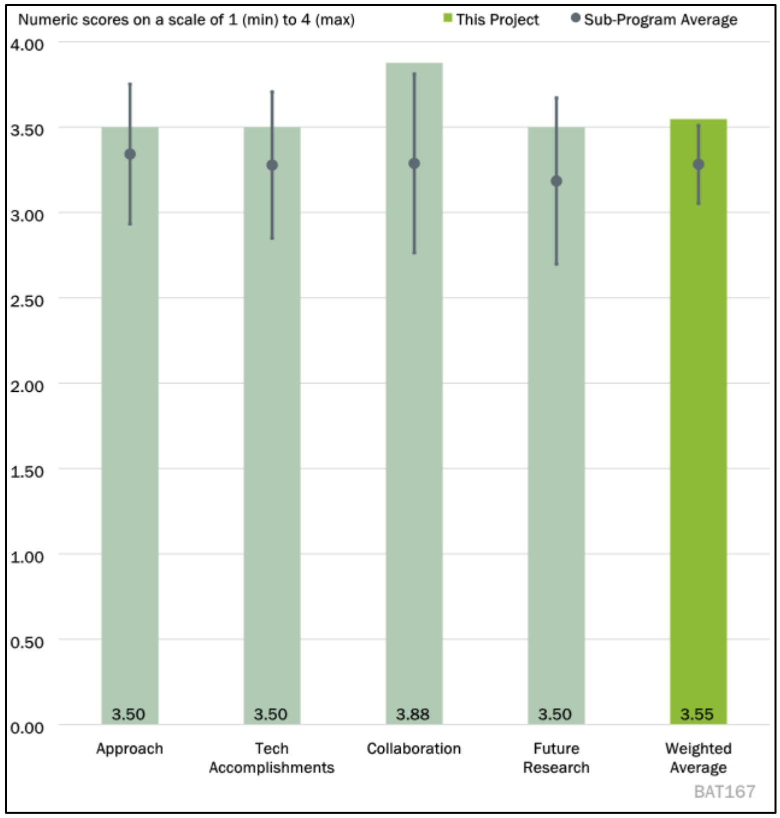

Figure 1-3 - Presentation Number: BAT167 Presentation Title: Process Development and Scale-Up of Advanced Active Battery Materials Principal Investigator: Ozge Kahvecioglu (Argonne National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer highlighted that the project had dual objectives: first, to supply the upstream with high-quality precursor cathode active materials (pre-CAMs) for the US battery research communities, aiding in the development of new CAM synthesis and innovative synthesis methodologies; and second, to devise manufacturing processes for pre-CAM and CAM that are both scalable to industry standards and cost-effective. The reviewer praised the program, noting its considerable successes and numerous technical achievements.

Reviewer 2:

The PI was acknowledged by the reviewer for directing a commendable array of research and development projects centered on CAM and pre-CAM evolution. The PI's adept use of continuous stirred-tank reactor (CSTR) and thermal vapor recompression (TVR) instruments within the Materials Engineering Research Facility (MERF) was noted. The reviewer expressed admiration for the extensive work undertaken by the PI, particularly emphasizing the significant progress in creating nickel manganese (NiMn) lithium-rich CAMs for earth-abundant cathode material (EaCAM).

Reviewer 3:

The reviewer emphasized that the project was thoughtfully designed, encompassing clear objectives that addressed both technical and financial aspects. The assembled team, as per the reviewer, was strategically chosen to facilitate rapid and reliable feedback.

Reviewer 4:

The reviewer remarked on the project's successful alignment with its defined objectives and the prevailing challenges in this sector. The organized and effective approach towards achieving specific targets was commended.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer highlighted the project team's significant role in supporting multiple VTO Batteries subprogram (BAT) projects in their research and development, notably BAT569, BAT183, and BAT402, along with numerous other battery programs. The team's commitment to catering to the specific needs of these projects by providing tailored high-quality pre-CAMs is noteworthy. They have shown agility in their research approach by continually refining and improving the synthesis procedures based on the requirements of the broader battery research community and scaling needs of battery manufacturers.

Reviewer 2:

The reviewer commented that the team, in its recent breakthroughs, has shifted towards the production of carbonate precursors. This move has curtailed the need for ammonia in the co-precipitation process when compared to the hydroxide route. Such innovations demonstrate a conscious effort towards making battery material production more environmentally friendly while also cutting down production costs.

Reviewer 3:

The reviewer noted that the PI's work is commendable. There has been a clear demonstration of progress and tangible outcomes across all the research projects under his/her leadership. One of the significant highlights being that the discharge capacity of most of the CAMs developed by the PI is on par, if not superior to, the current state of the art.

Reviewer 4:

The reviewer stated that BAT167A's study is thorough and astutely addresses both the technical and economic facets of cathode materials for LIBs. The reviewer posed certain critical questions to the PI and the team, especially concerning their presentation on Slide 6. The queries revolve around the lithium manganese rich-nickel manganese cobalt material (LMR-NMC) synthesis, its time efficiency, particle integrity in the fast vs. slow carbonate routes, and potential discrepancies in the cathode calendering process for the two routes. Further, there is curiosity about the significance of the TVR method in commercial cathode manufacturing. A suggestion was also provided, emphasizing the potential benefits of researching the impact of Li salt particle size on cathode material synthesis and performance. Lastly, the reviewer praised the project's holistic approach, especially the utilization of real-time particle tracking and multi-scale modeling. It's evident that the project is fulfilling its objective of supplying materials to other laboratories and projects, which aligns with its overarching mission. However, the reviewer also pointed out areas that could benefit from further elaboration, such as understanding the behavior of particle aggregates and connecting them to specific processing steps.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer commended the collaborative nature of the project, showcasing a synergistic relationship between the project and the broader battery research communities. The collaborations span a multitude of research directions, highlighted by partnerships with entities such as the DRX+ consortium and those focusing on EaCAM.

Reviewer 2:

The reviewer noted that the Materials Engineering Research Facility (MERF) inherently demands the synthesis and development of preCAMs and cathode active materials (CAMs). The PI's ability to excel in this domain is evidenced by the high quantity and quality of the preCAMs and CAMs that have been developed. These achievements underscore the PI's cooperative and collaborative spirit. Her commitment to supporting various projects, ensuring their success, stands out prominently.

Reviewer 3:

The reviewer stated that the project's collaboration is all-encompassing, reaching beyond just the ANL. Noteworthy partnerships with institutions like the Brookhaven National Laboratory (BNL) and Virginia Tech have been instrumental in bringing pivotal insights that have furthered the project's objectives.

Reviewer 4:

The reviewer underlined the widespread collaborations with esteemed academic institutions and national laboratories in the project's comprehensive approach.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer highlighted the team's clear understanding of the remaining challenges. They've outlined a future research plan that addresses the US battery community's needs regarding active cathode materials. A significant milestone would be the team's development of procedures that eliminate the use of ammonia in pre-CAM production.

Reviewer 2:

The reviewer appreciated the thoughtfulness of the plan, particularly emphasizing the strategies laid out for the EaCAM consortium.

Reviewer 3:

The reviewer underscored the importance in future work of understanding the stability of Mn in a hydroxide precursor. The idea of replacing other metal ions for Co was also flagged as noteworthy, with a call to delve into the implications of introducing different non-transition metal ions on both structural and electrochemical performance.

Reviewer 4:

The reviewer noted that the proposed research is well-aligned with the identified challenges.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer emphasized that the synthesis of CAMs is pivotal to the development of Li-ion batteries. The efforts of the project play a vital role in propelling vehicle electrification forward, aligning with the primary objective of VTO.

Reviewer 2:

The reviewer noted the importance of the PI’s work in relation to VTO objectives. Given that the CAM accounts for about one-third of the cost of Li-ion cells for EVs, the development of innovative preCAMs, CAMs, and their fabrication methods becomes incredibly pertinent to VTO goals.

Reviewer 3:

For the reviewer, the role of the cathode in determining the electrochemical performance of a LIB is indispensable. Thus, the need for a synthesis method that’s both scalable and cost-effective becomes paramount.

Reviewer 4:

The reviewer pointed out that one of VTO’s key goals is the development of cost-efficient, optimized processes for electrode fabrication.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer highlighted the proficiency of the project team in materials processing. Coupled with extensive collaboration with national laboratories, universities, and industry, the team is well-equipped with the necessary resources and capabilities to meet their milestones in a timely manner.

Reviewer 2:

The reviewer appreciated the increment in funding for FY 2023, noting its importance especially in light of inflation.

Reviewer 3:

The reviewer reiterated that the formation of the team aligns well with the project’s objectives.

Reviewer 4:

The reviewer observed that the resources available to the team match the proposed objectives.

Presentation Number: BAT168
Presentation Title: Process Development and Scale-Up of Critical Battery Materials - Continuous Flow-Produced Materials
Principal Investigator: Krzysztof Pupek (Argonne National Laboratory)

Presenter

Krzysztof Pupek, Argonne National Laboratory

Reviewer Sample Size

A total of six reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 67% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 33% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

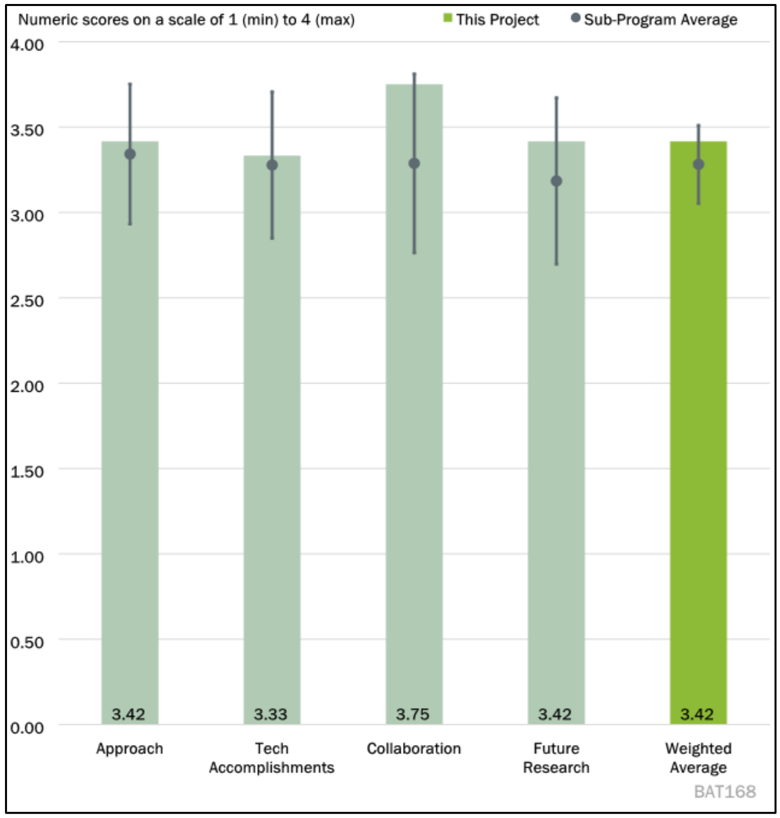

Figure 1-4 - Presentation Number: BAT168 Presentation Title: Process Development and Scale-Up of Critical Battery Materials - Continuous Flow-Produced Materials Principal Investigator: Krzysztof Pupek (Argonne National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer noted the project's promising approach to scaling up emerging Li salts and solvents for the development and evaluation of new electrolytes. They commended the well-designed structure of the project, especially its focus on cost-effective continuous processes. However, the reviewer provided specific feedback on certain aspects. Firstly, they suggested a literature review for optimizing F-DCI and referenced a relevant paper. Secondly, they emphasized the need to improve the selectivity and yield of FMMB. Lastly, they recommended deeper engagement with organic synthetic chemists to better understand reaction mechanisms.

Reviewer 2:

The reviewer acknowledged the advantages of continuous flow chemical synthesis over traditional batch production and highlighted its benefits, including high throughput and better quality control. The reviewer also suggested the PI offer more details on the separation technology, emphasizing potential challenges with traditional preparation quality control systems.

Reviewer 3:

The reviewer found that the project articulates technical barriers well and viewed the project scope and timeline as generally reasonable.

Reviewer 4:

The reviewer remarked on how effectively the project addresses technical barriers in electrolyte development. They praised the project's aim of developing a continuous flow process, emphasizing its crucial importance and potential for bridging bench-top chemistry and large-scale manufacturing. They also highlighted the project's synergy with other DOE programs.

Reviewer 5:

The reviewer observed the team's effective addressing of the technical barrier. They expressed confidence in the group's use of continuous flow chemistry and the involvement of the MERF, deeming the timeline both reasonable and feasible.

Reviewer 6:

The reviewer appreciated the team's approach, especially the identification of materials developed by other groups critical for scale-up research and commercialization. They also emphasized the potential of the team's continuous flow process for large-scale production, once validated.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer noted that the technical progress aligns well with the project plan for FY 2023. They emphasized the completion of lithium tricyanoimidazole (Li-TCI) via diazotiation chemistry and the development of a continuous flow process for certain compounds. Additionally, they mentioned the ongoing processes for scaling up various compounds, concluding that the milestones for FY 2023 have been met.

Reviewer 2:

Another reviewer noted the use of the continuous flow technique for synthesizing several additive compounds and conducting basic corrosion tests. They encouraged the PI to offer more specifics on product yield and stability. They also stressed the need to investigate the interaction of additives with various components of the battery.

Reviewer 3:

The reviewer lauded the project, noting the team's expertise in liquid electrolyte characterization and research techniques.

Reviewer 4:

The reviewer recognized the team's extensive progress in line with the project plan for FY 2023, emphasizing the synthesis and molecular characterization efforts. The reviewer also mentioned the team's future plans for electrochemical tests.

Reviewer 5:

The reviewer applauded the team's synthesis of Li-TCI, Li-F-DCI, and their initiative to scale up LiBHFip. They acknowledged the synthesis of various fluorinated compounds and highlighted the high selectivity achieved for FMMB. The reviewer found the imidazole-based salts and fluorinated solvent integral to battery research.

Reviewer 6:

The reviewer praised the team's progress, emphasizing their synthesis of lithium borate ester salts and fluorinated butanediol ethers. They regarded these ethers as promising solvents for Li metal batteries. The reviewer also mentioned the team's investigation into the corrosion behavior of different electrolytes using specific tests, deeming these findings essential for future research.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer acknowledged this project's extensive collaboration and coordination efforts with ANL, academic institutions, other national laboratories, and industry right from the beginning. They emphasized how these collaborations have been fundamental to ensuring planned progress and upholding the project's integrity.

Reviewer 2:

The reviewer highlighted the vast array of collaborators, spanning national laboratories, universities, and industries. However, they called on the PI to provide tangible evidence showcasing the advantages of such an extensive collaborative network.

Reviewer 3:

The reviewer commented positively on the team's effective management of partnerships with synergistic collaborators.

Reviewer 4:

The reviewer lauded the MERF project as a shining example of successful collaboration among industry, academia, and national laboratories. They noted the team's provision of a list of electrolyte molecules for the wider battery community and did not express any concerns regarding additional collaborations.

Reviewer 5:

The reviewer highlighted the MERF's extensive collaborations with both academia and industry. They pointed out the benefits of distributing large quantities of new materials to the battery community. This process accelerates the investigation and evaluation of new materials and simultaneously supports the broader battery research community.

Reviewer 6:

The reviewer celebrated the team's outstanding collaborative efforts with various research groups and industries. Through these collaborations, they gain insights into the most promising materials for scaling up and identify critical barriers to overcome. For instance, the reviewer mentioned the FDMB solvent as a prime example of a material that, once scaled up, could propel advancements in Li metal battery development.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer recognized the project's well-defined purpose for its future endeavors. Emphasizing the plan to optimize continuous flow chemistry for scaling up the production of new Li salts and fluorinated solvents, they see it as a significant step towards speeding up the development of new electrolytes for Li-based batteries.

Reviewer 2:

This reviewer touched upon the project's future focus areas, including battery testing, green processes, further flow process optimization, and quality assurance. They suggested the PI to particularly concentrate on refining separation technology to ensure quick and efficient harvesting of the pure product.

Reviewer 3:

The reviewer commended the project's clear and reasonable future plans. However, they mentioned the potential challenges with coin cells, suggesting that the team might want to validate the selected electrolytes using pouch cells when approaching the project's conclusion.

Reviewer 4:

The reviewer reiterated the project's well-structured future purpose and plan for the upcoming fiscal year. They cautioned the team against extensive proposed work, urging them to remain focused on essential tasks. They also hinted at the potential advantages of integrating tasks related to techno-economic analysis (TEA).

Reviewer 5:

The reviewer pointed out that the future research seems like a natural progression of the current research, with clear purposes. Given the PI's collaborations and detailed timelines, they believe that the plans will be executed on schedule.

Reviewer 6:

The reviewer highlighted the excellent future work research plan, advising the team to stay updated with the latest advancements in the field. They mentioned the potential outdatedness of some materials before their scale-up, referring to a next-generation fluorinated butanediol ether developed by the Stanford group. They suggested considering this new material for future scaling up efforts, potentially even replacing the project's current target.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer acknowledged the project's alignment with the VTO subprogram objectives. They emphasized its crucial role in bridging the gap between the invention of advanced battery materials and their high-volume manufacturing. This project, in their opinion, ensured a swift and effective assessment of emerging materials, enhancing outcomes of the VTO projects.

Reviewer 2:

The reviewer highlighted the project's relevance to the VTO objectives, noting its potential to contribute to cost-effective, high-volume production of essential chemicals for Li batteries.

Reviewer 3:

The reviewer pointed out the project's high relevance to various VTO subprograms, particularly those focusing on Li-ion and possibly Li-S technologies.

Reviewer 4:

The reviewer underscored the project's pivotal importance in supporting the overarching VTO subprogram objectives. They noted that while the project was in a fundamental phase, its future implications could be significant.

Reviewer 5:

The reviewer brought attention to the project's achievements, such as the development of imidazole-based salts and new fluorinated solvents. With the synthesis of numerous samples aiding battery research groups, they affirmed the project's alignment with VTO objectives.

Reviewer 6:

The reviewer commended the project's strong association with the development of novel materials in the domain. They reiterated its valuable contribution to achieving the broader VTO subprogram objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that the resources had been sufficient for the project to reach its stated milestones promptly. They highlighted the comprehensive resource list that included the MERF at ANL, electrochemical testing and characterization facilities, both at ANL and with project partners, and technical assistance from academic institutions for flow chemistry optimization.

Reviewer 2:

The reviewer emphasized that, given the resources at ANL and collaborators, the team had more than adequate resources for the project they had proposed.

Reviewer 3:

The reviewer mentioned that the resources had been sufficient.

Reviewer 4:

The reviewer noted that the project had been well-resourced to complete its tasks. They mentioned the state-of-the-art facility and believed the funding level had been apt for supporting the project. The reviewer also expressed a wish for the wider community to offer swift feedback on electrolyte performance and recognized the potential need for dedicated efforts in analyzing battery data as it amassed towards the project's conclusion.

Reviewer 5:

The reviewer pointed out that there had been ample resources to complete the project, including certain aspects like materials synthesis and scale-up, characterization, electrochemical testing, and valuable feedback from collaborations.

Reviewer 6:

The reviewer observed that the project's resources had been adequate. They suggested the potential of channeling these resources into the development of fewer materials to expedite their progress.

Presentation Number: BAT226
Presentation Title: Probing Interfacial Processes Controlled Electrode Stability in Rechargeable Batteries
Principal Investigator: Chongmin Wang (Pacific Northwest National Laboratory)

Presenter

Chongmin Wang, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

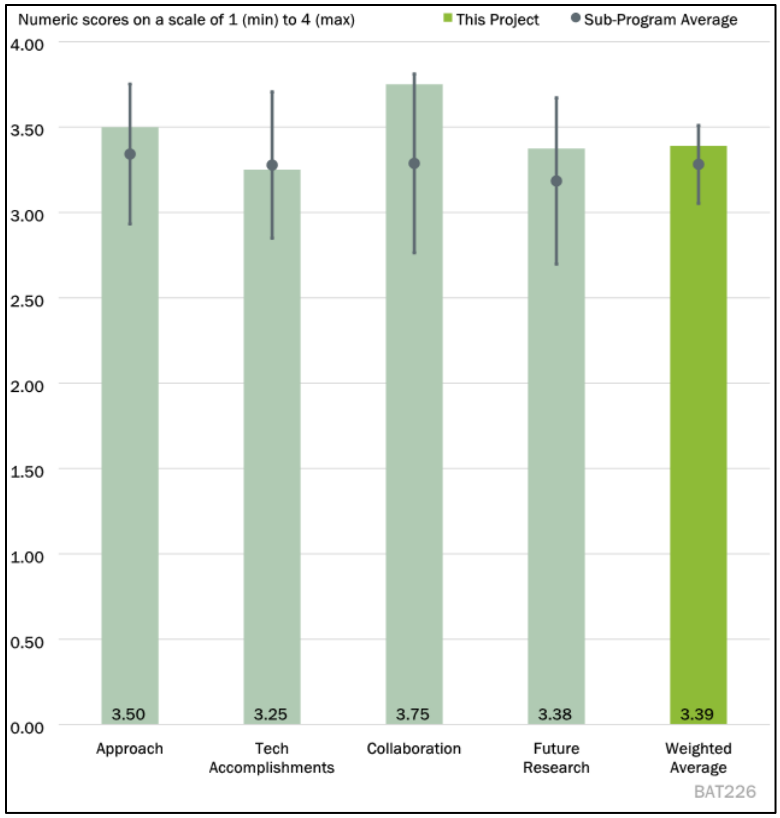

Figure 1-5 - Presentation Number: BAT226 Presentation Title: Probing Interfacial Processes Controlled Electrode Stability in Rechargeable Batteries Principal Investigator: Chongmin Wang (Pacific Northwest National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer mentioned that the PI had employed a highly logical approach to explore the electrical attributes of the SEI. They emphasized the project's significance in identifying and characterizing the SEI structure and properties based on the electrolyte chemistry. The reviewer appreciated the project's well-thought-out design and its contribution to overcoming the known challenges.

Reviewer 2:

The reviewer commented that the authors had utilized an impressive range of techniques that targeted crucial questions related to the SEI.

Reviewer 3:

The reviewer acknowledged the project's structured design, feasible timeline, and the appropriate selection of characterization tools. They commended the approach that distinctly assessed the influence of various components in the electrolyte on the SEI's properties formed with Li metal. The integration of experimental findings with simulations to discern the reasons for observed behaviors during characterization was also well-regarded by the reviewer.

Reviewer 4:

The reviewer asserted that the project had been well-crafted with a fitting timeline. They highlighted the exceptional spatial resolution of transmission electron microscopy (TEM) tips and inquired if any variance in electronic properties had been observed across different SEI layer locations.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer acknowledged the exceptional technical progress of the project. They commended the PI and collaborators for addressing the identified issues using an array of high-grade tools and instruments, and through effective collaboration with specialists in relevant domains. The reviewer then suggested some points for further exploration: (1) Regarding the phenomenon of Ni dissolution and its migration to the anode side, the PI's reference to a catalytic effect needed more clarity; and (2) The reviewer sought details about how the parameters for the Li growth phase field model were determined.

Reviewer 2:

The reviewer remarked that the project was in its early stages. They noted that the authors had identified several intriguing correlations, and they would need to discern the causative factors from the resultant effects.

Reviewer 3:

The reviewer highlighted the substantial technical advancements made relative to the project's blueprint. They emphasized the project's achievements in decoding the effects of varied electrolyte constituents, including dissolved Ni and both inorganic and organic components, on the SEI's electronic conductivity. A deeper explanation about how these components amalgamate into the SEI and cause the observed changes in electronic properties would provide a profound comprehension of the SEI's dynamics. The project's insights into the SEI's microstructure and its implications on Li growth, as portrayed via phase field simulations, were appreciated. The reviewer felt that elaborating on the significance of specific microstructures, like the denser presence of Li_2O nanoparticles in the whiskers, would be beneficial.

Reviewer 4:

The reviewer praised the innovative use of the TEM probe (W) to measure the SEI layer's electron leakage. They sought clarity on how the distance between the W-tip and the electrode surface was maintained to ensure that the captured current was both scientifically meaningful and replicable.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer commended the PIs for their outstanding collaborative strategy, noting that it significantly bolstered the experimental results.

Reviewer 2:

The reviewer praised the team's collaborations, terming them as "excellent."

Reviewer 3:

The reviewer acknowledged the robust collaboration evident within the project team. They emphasized the seamless integration of cathode materials from various national laboratories, solid-state components and modeling contributions from university affiliates, and the support in forging new characterization capabilities received from external partners. The reviewer appreciated the clarity with which each partner's contributions were delineated.

Reviewer 4:

The reviewer affirmed the high quality of collaboration within the team.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer highlighted that the proposed work fits seamlessly with the ongoing approach, and there's a clear trajectory towards delving deeper into interfacial phenomena.

Reviewer 2:

The reviewer labeled the project's directions as "promising."

Reviewer 3:

The reviewer recognized the targeted focus of the future endeavors on understanding the interactions between cathodes and SSEs in Li-ion solid-state and Li-S solid-state systems. They commended the project for its potential in addressing the challenges surrounding interfacial stability in SSBs. However, the reviewer also expressed a desire for clearer confirmations of the adaptability of the techniques to situations where both interfacing materials are solid.

Reviewer 4:

The reviewer positively commented on the clarity of the project's future research intentions.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer noted that the project's focus aligns with the VTO subprogram's goals, especially in gaining a deeper understanding of the SEI formation and its relation to various electrolyte chemistries.

Reviewer 2:

The reviewer acknowledged the significance of SEI in battery research. While noting that the SEI issue in liquid systems has largely been addressed by battery industries through empirical methods, the reviewer emphasized that advancements in resistance against dendrite formation remain invaluable.

Reviewer 3:

The reviewer stressed the project's relevance and emphasized the importance of understanding SEI for the progression and adoption of Li metal anodes, which supports the VTO's objectives.

Reviewer 4:

The reviewer posed critical questions related to the study's methodology and its applicability in practical scenarios. Specifically, they queried how the insights derived from using a low vapor pressure lean high-capacity electrolyte (LHCE), due to the unique requirements of TEM, would be applicable to systems that utilize carbonate-based electrolytes. The reviewer sought clarity on whether the project's findings would hold true for alternative electrolyte systems.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that the resources appear sufficient to achieve the stated milestones.

Reviewer 2:

The reviewer commented that the resources are sufficient.

Reviewer 3:

The reviewer said that the resources are sufficient for the project to achieve the stated milestones.

Presentation Number: BAT230
Presentation Title: Nanostructured Design of Sulfur Cathode for High-Energy Lithium-Sulfur Batteries
Principal Investigator: Yi Cui (Stanford University/SLAC National Accelerator Laboratory)

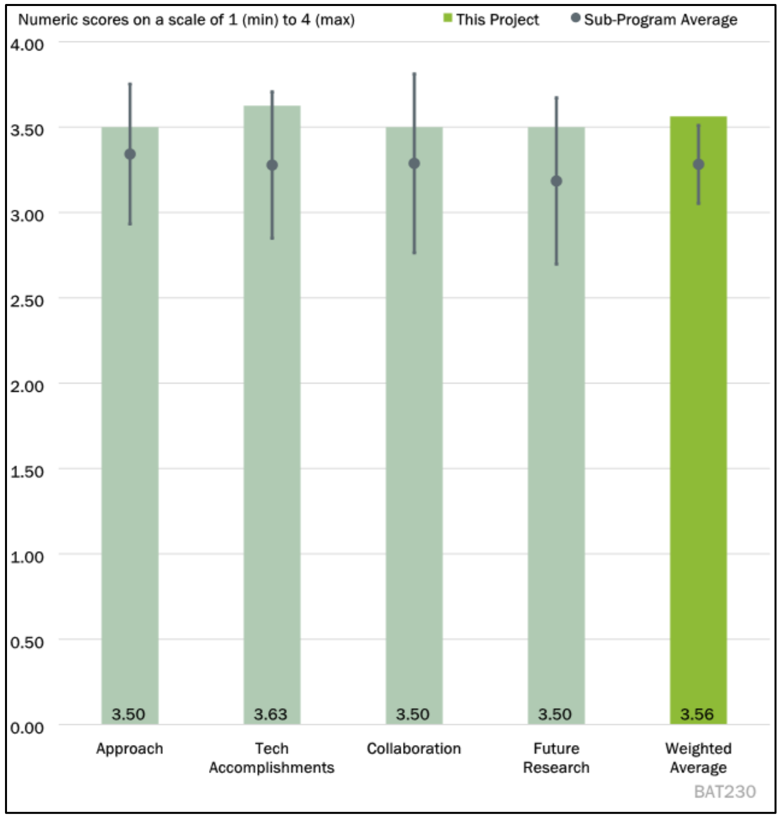

Figure 1-6 - Presentation Number: BAT230 Presentation Title: Nanostructured Design of Sulfur Cathode for High-Energy Lithium-Sulfur Batteries Principal Investigator: Yi Cui (Stanford University/SLAC National Accelerator Laboratory)

Presenter

Yi Cui, Stanford University/SLAC National Accelerator Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 25% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer commented that while the project has clear objectives, there was difficulty in understanding how these objectives were achieved due to insufficient explanations. The reviewer highlighted specific areas, such as the concept of nanoscale encapsulation, the nature of functional coatings used, and the choice of redox mediators, that were inadequately explained.

Reviewer 2:

The reviewer noted that the project integrated knowledge in nanostructured S cathode design with the use of mediators to address challenges faced by all-solid-state lithium-sulfur (Li-S) batteries. They appreciated the use of advanced characterization to gain insights into the failure mechanisms of the cells and the degradation of electrode materials during their operation. The overall project design and timeline were deemed satisfactory by the reviewer.

Reviewer 3:

The reviewer recognized the project’s intentions to enhance the life cycle of sulfur cathodes by introducing novel encapsulation methods at nanoscale and developing new sulfur nanostructures with multifunctional coatings. The present focus on developing redox additives to enhance sulfur kinetics was acknowledged, especially in the context of solid electrolyte systems. However, the reviewer pointed out certain potential drawbacks: the need for scalability of the developed methods, concerns regarding the choice of Co for the redox additive due to supply issues, and doubts about the uniqueness of the material in light of similar studies.

Reviewer 4:

The reviewer summarized the project's aim to develop cost-effective and high energy density Li-S batteries suitable for EVs. They detailed the project's approach, which includes designing innovative sulfur cathodes with multifunctional coatings to tackle various challenges, and the development of redox mediators to support the high energy density requirements of all-solid-state Li-S batteries.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer mentioned that while the introduction of redox mediators and single-atom catalysts showed potential in improving the charge, it would be beneficial for more details to be included in the poster presentation, especially if the work has been previously published. The reviewer acknowledged the complexity of the project and emphasized that even minor advancements are valuable given the challenging nature of the project.

Reviewer 2:

The reviewer highlighted two significant accomplishments of the team: (1) the design of a new redox mediator that enhanced sulfur utilization in all-solid-state Li-S batteries, achieving an impressive cell energy density; and (2) the development of a Co single atom catalyst that optimized both sulfur utilization and reduced overpotential. The reviewer further appreciated that these advancements were published in reputable journals.

Reviewer 3:

The reviewer noted that progress had been made in creating a single atom catalyst to facilitate Li-S conversion, resulting in improved battery performance in terms of capacity and reduced overpotential. These achievements were documented in peer-reviewed articles. However, the reviewer raised concerns regarding sulfur utilization, sulfur loading, and the impact these factors have on battery performance. They also pointed out an unaddressed task related to testing cathodes with high capacity and high-rate ability, emphasizing its importance.

Reviewer 4:

The reviewer summarized the advancements made in the project, underscoring the development of all-solid-state Li-S batteries augmented by redox mediators and the impressive energy density achieved. Additionally, the incorporation of Co single atoms facilitated a rapid Li-S conversion in the batteries, with promising capacity and overpotential results.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer emphasized the significance of collaborations, noting that they serve to enhance and bolster the project.

Reviewer 2:

The reviewer stated the project has integrated expertise from notable institutions like SLAC/Stanford University, and PNNL, bringing together professionals specialized in material synthesis, advanced characterization, and pouch cell testing. The diversified skills of the team mesh well together, creating a complementary ensemble.

Reviewer 3:

The reviewer identified several collaborations, mentioning relationships with respected faculty members from Stanford and researchers from other prominent institutions. However, the reviewer expressed concerns regarding the lack of clarity surrounding certain collaborations, specifically those with the Battery500 (B500) team outside of Stanford, as well as PNNL or INL. They highlighted the necessity of suitable collaborations, possibly involving a battery company or a national laboratory, for tangible cell-level demonstrations. Without these partnerships, the reviewer feared that such technologies might remain restricted to the material level, impeding their progression to higher technology readiness levels (TRL).

Reviewer 4:

The reviewer praised the project's association with esteemed professors from Stanford University, recognizing the importance of their expertise in redox mediator synthesis and optical characterization. Additionally, collaborations with SLAC and PNNL were also highlighted as valuable.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer stated that there are several pivotal aspects of the project that the team needs to further delve into. One such pivotal point is the underlying mechanism of the single-atom catalyst, which has not been fully elucidated in the current report.

Reviewer 2:

The reviewer remarked that from the plans shared, it appears that the team is gearing up for an in-depth advanced characterization and simulation to gain insights into the operational principles of both the redox mediator and the single atom catalyst. Achieving this deeper understanding could be instrumental in realizing further advancements, particularly in the realms of areal sulfur (S) loading and rate capabilities in all-solid-state Li-S batteries.

Reviewer 3:

The reviewer commented that given the project is to conclude in 2023, there are reservations on how much the team can accomplish, especially in terms of tangible hardware demonstrations, in the available timeframe. While there's an expressed intent to uncover the working mechanism of the single-atom catalyst in solid-state Li-S cells via both experimental and theoretical approaches, the scope of demonstrations of high capacity and enhanced rate capability all-solid-state lithium-sulfur batteries (ASSLSBs) within the project's current span is not clearly established.

Reviewer 4:

The reviewer observed that the team has clearly outlined the challenges ahead, such as achieving and maintaining high capacities and stability in Li-S batteries, and the nuances associated with increasing the mass loading of active sulfur in the cathode. Addressing concerns like enhancing the rate capability in the context of SSEs and handling the diffusion of sulfur species are crucial. The roadmap includes *operando* X-ray absorption spectroscopy measurements, high areal mass loading tests for sulfur cathodes, and an exploration of the mechanism of the single-atom catalyst in ASSLSBs. The reviewer is keen to see the navigation through these challenges and the resulting advancements in ASSLSBs, especially on marrying high capacity with high-rate capability.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer stated that the project's alignment with the VTO subprogram's focus on advancing Li/S batteries is evident and commendable. This establishes the relevance of the project's goals in the broader context of the subprogram's objectives.

Reviewer 2:

The reviewer commented on the project's emphasis on the development of high-energy, low-cost all-solid-state Li-S batteries. Such advancements can potentially address the limitations of current LIBs, especially in energy density, cost, safety, and supply chain challenges. This focus aligns with the VTO's aspirations to pave the way for cutting-edge batteries suitable for automotive applications.

Reviewer 3:

The reviewer affirmed that the project's efforts resonate with DOE's broader objectives. By pioneering the development of Li-S solid-state cells boasting enhanced safety, improved cycle life, lower costs, and higher specific energy, the project underscores its commitment to meeting these objectives. The experience and knowledge accumulated from prior B500 team research on liquid electrolyte systems have indeed highlighted significant challenges. These include issues related to polysulfide shuttling and anode stability. Recognizing this, the project's shift towards solid electrolyte systems, especially with its focus on innovative solutions like nanoscale coatings and single-atom catalysts, is both strategic and timely. The reviewer expressed that this direction reaffirms the project's alignment with the objectives and goals of the DoE VTO's battery program.

Reviewer 4:

The reviewer articulated that the project's content directly addresses the primary barriers plaguing battery storage solutions. By targeting challenges such as high costs, limited energy density, reduced battery lifespan, and safety concerns, the project manifests its commitment to revolutionizing the battery storage domain.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that the resources available to the project are sufficient.

Reviewer 2:

The reviewer commented that the collaborative nature of the project, involving scientists from various institutions possessing complementary skills and capabilities, ensures that there are ample resources to effectively undertake and complete the proposed work.

Reviewer 3:

The reviewer observed that, in the context of the overall B500 project, the resources seem to align well with the project's scope. They even suggested that the resources might be slightly on the generous side, especially considering the nature of university research and development endeavors.

Reviewer 4:

The reviewer affirmed that the allocated funds are proportional to the scope of work. The evident progress and significant findings further validate this assertion.

Presentation Number: BAT232
Presentation Title: High Energy Density Electrodes via Modifications to the Inactive Components and Processing Conditions
Principal Investigator: Vincent Battaglia (Lawrence Berkeley National Laboratory)

Presenter

Vincent Battaglia, Lawrence Berkeley National Laboratory

Reviewer Sample Size

A total of six reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

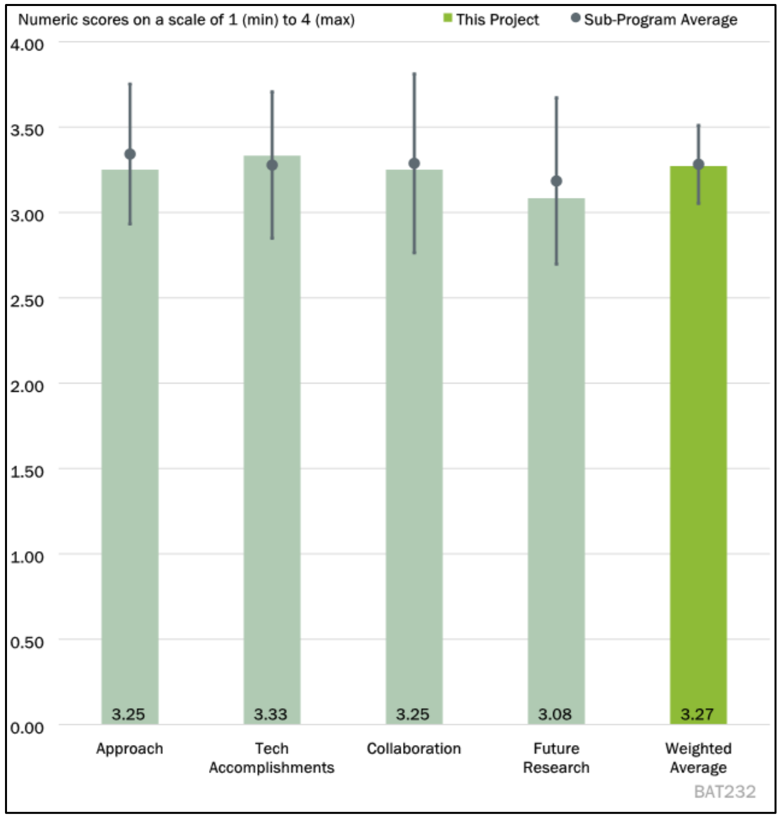

Figure 1-7 - Presentation Number: BAT232 Presentation Title: High Energy Density Electrodes via Modifications to the Inactive Components and Processing Conditions Principal Investigator: Vincent Battaglia (Lawrence Berkeley National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer remarked that the project's approach emphasized understanding the interplay between electrode ingredients and coating properties. Specifically, they commended the team's initiatives to minimize inactive fractions, enhancing overall capacity. The exploration of carbon additives and the sequence of mixing are also highlighted. Nonetheless, the reviewer provided constructive feedback: (1) proposing the integration of a statistical Design-of-Experiment methodology to better grasp the interplay and primary factors; (2) emphasizing the importance of comprehending the density and porosity of the coating; and (3) focusing on the optimal use of active material at elevated rates.

Reviewer 2:

The reviewer observed a certain lack of meticulousness in the presentation. They noted errors like misspellings in the project title on the initial slide and overlooked comments left in the margins. While the attempt to use a green highlight for clarity was appreciated, the presentation's organization needed improvement. Despite these oversights, the reviewer acknowledged that the project's approach, especially regarding the study of mixture components on the synthesized cathode, was detailed and well thought out. However, they also felt that the project's progression seemed a bit slow, considering the outlined objectives.

Reviewer 3:

The reviewer articulated that the project's ambitions and challenges were evident. They emphasized the significance of understanding processing conditions and their effects on electrode performance. The current approach might require revisiting, especially considering dispersion challenges with certain materials. The reviewer provided specific suggestions like verifying the mix's homogeneity with a Hegman gauge and focusing on the coating's durability during subsequent electrode processing steps. They also shared insights from personal experience on the potential issues of coatings with low binder content.

Reviewer 4:

The reviewer stated that while the project's approach was comprehensive and catered to immediate needs in cell production, it missed out on addressing some fundamental research linked to the technical barriers. There was a clear emphasis on understanding the slurry process and real-time particle size analysis, but it was essential to consider the broader technical objectives.

Reviewer 5:

The reviewer praised the project's design, emphasizing its precision and targeted scope. They commented that the project's tight focus ensured the realization of the set objectives. Yet, they also cautioned against any unwarranted expansion in scope, which might compromise the timeline.

Reviewer 6:

The reviewer affirmed that the report did a commendable job in concentrating on carbon additives and binders. The approach showed promise in addressing the technical barrier about cycle life and provided insights that could be vital for surmounting challenges related to high specific power and energy.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer observed that the technical progress is closely following the project plan. The reviewer commented that a baseline process has been established on NMC/Denka black/polyvinylidene fluoride (PVDF) mix, which makes the study on new additives and new active materials more systematic. The reviewer commented that a new focus on lithium iron phosphate (LFP) cathode is a good example that the knowledge cumulated from the systematic study can be applied to the new chemistries.

Reviewer 2:

The reviewer commented that it was difficult to find significant improvements on the technical progress.

Reviewer 3:

The reviewer stated that given the smaller particle size of LFP compared to NMC, one should expect a need for more solvent to achieve target coating viscosity. In addition to yield stress measurement, it may be helpful to look at time-dependent behavior like thixotropy or structure-recovery, if these have an impact on the coating quality.

Reviewer 4:

The reviewer commented that different carbon materials, different CAM, binder etc. were investigated. The conductivity and slurry viscosity were measured. Scanning electron microscopy (SEM) was used to investigate the surface morphology. The PI was recommended to test the coated electrode in either a half cell or full cell.

Reviewer 5:

The reviewer commented that the progress is slow. The reviewer observed that carbon and solvent appear like one variable to be tuned simultaneously to ensure the optimum conditions for adherence to the electrode without loss of the active material. The current analysis is useful to show the degree of entanglement of the several components, but the reviewer stated that further work is needed for a better understanding of the impact of the various processes (mixing, drying, etc.). The reviewer had the following additional questions/observations: (1) The chemistry and specially the interfacial properties of the carbon/cathode material (for example NMC vs LFP) may be important but were not discussed here; (2) Slurry formulations: what does it mean: "Amount of solvent modified based on 'feel' of coating expert?"; and (3) Viscosities: it is not clear what can be learned from the graph on Slide 34.

Reviewer 6:

The reviewer commented that a wide array of data has been shown on slurry formulations, the effect of changing carbons, and how changing slurry components influences the electrode conductivity, adhesion, and morphology. The technical achievements and progress support the program milestones well. As was stated for the approach though, only 3 slides (Slides 7, 13, and 21) address the technical barriers and no slides mentioned how the research applies to cell energy density and/or power.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer stated that while the PI has engaged in collaborations with other DOE programs, universities, and companies, it would be beneficial for the PI to consult with cell manufacturers to gain deeper insights into critical properties during production.

Reviewer 2:

The reviewer observed that there seems to be in use a proactive approach towards discussions and collaborations with teams at other national laboratories and industry stakeholders working on similar challenges.

Reviewer 3:

The reviewer commented on the evident collaboration with various commercial binder and carbon suppliers. They expressed interest in understanding the rationale behind the selection of specific binders for certain formulations.

Reviewer 4:

The reviewer remarked that the project has showcased its collaborations with other government entities and private organizations, providing brief overviews of the collaborative activities. They observed that while there has been significant collaboration with national laboratories, engagement with only one company (Arkema) was mentioned. The reviewer suggested that further industry partnerships would be a valuable addition.

Reviewer 5:

The reviewer praised the project's collaborative efforts, emphasizing the importance of engagement with material suppliers and analytical service providers in such projects. They affirmed that the project has adeptly managed its coordination among all parties involved and has aptly acknowledged their contributions.

Reviewer 6:

The reviewer recognized the effective collaboration between the industry and national laboratories in conducting the research. They suggested that the team use industrial production machinery to validate the findings derived from laboratory equipment further.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer remarked that while the PI is set to further delve into the contributions of carbon, binder, and solvents, there might be added value in considering a larger batch size for a more representative sample.

Reviewer 2:

The reviewer commented that the planned work seems to address some pivotal remaining challenges. However, given the numerous objectives, it might be beneficial to determine and prioritize the most pressing objectives first and then schedule the activities accordingly.

Reviewer 3:

The reviewer suggested that although comparing NMCs or LFPs from different suppliers could provide more insight, it might stray from the main focus of the study. They also stated that a visit to a few electrode manufacturing sites to observe larger-scale mixing, coating, and drying processes might yield additional insights.

Reviewer 4:

The reviewer observed that the proposed future work, while extensive, lacks some clarity in terms of how it directly aims to address certain goals like achieving 1000 cycles or reaching 350 Wh/kg, even though the work will inevitably influence electrochemical performance.

Reviewer 5:

The reviewer encouraged the investigator to reflect on the most effective design rules derived from present and forthcoming work. They emphasized the importance of communicating these rules clearly and prioritizing them in the project's concluding phases.

Reviewer 6:

The reviewer praised the project, noting that the objectives for the upcoming work have been well-articulated and they align harmoniously with the stated technical barriers.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer stated that the project's significance lies in its focus on the processibility of electrode manufacturing, a critical component of battery production.

Reviewer 2:

The reviewer articulated that refining and optimizing the processes involved in electrode production is vital for the progression of VTO objectives.

Reviewer 3:

The reviewer affirmed that possessing robust foundational knowledge on processing is essential when creating new designs. They stressed that any design efforts could be undermined by subpar processing conditions. Hence, they deem this project of paramount importance, ensuring that any prototypes are manufactured accurately and consistently.

Reviewer 4:

The reviewer observed that the program aligns well with the VTO subprogram's objectives, particularly in developing batteries that boast high cycle life and exceptional energy/power ratios for emerging chemistries.

Reviewer 5:

The reviewer commented that the project aims to propose ways to reduce the cost of LIBs while also identifying strategies to enhance battery longevity. While they believe the potential for cost-saving is modest, they see the project as an opportunity to potentially refine manufacturing outputs and elevate the predictability and consistency of product performance.

Reviewer 6:

The reviewer said that the project remains dedicated to enhancing electrode formulations and processability, reinforcing the broader objectives set by the VTO subprogram.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that the PI is well-equipped with the necessary resources to carry out the planned research.

Reviewer 2:

The reviewer expressed that while the resources are adequate, there’s a need for improved planning to maximize their utilization.

Reviewer 3:

The reviewer observed that given the diverse range of active materials under development, there will likely be an increasing need for projects like this one. They suggested that after examining NMC622 and LFP, it would be wise to determine other materials that might be suitable candidates for evaluation.

Reviewer 4:

The reviewer commented that the resources available for the program appear to match the scope of work being carried out.

Reviewer 5:

The reviewer remarked that there are no discernible issues concerning resources at this juncture of the project.

Reviewer 6:

The reviewer clarified that, based on the presented progress report, the resources at hand are sufficient for the project to meet its outlined milestones in a timely manner.

Presentation Number: BAT280
Presentation Title: Novel Chemistry: Lithium-Selenium and Selenium-Sulfur Couple
Principal Investigator: Khalil Amine (Argonne National Laboratory)

Presenter

Khalil Amine, Argonne National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

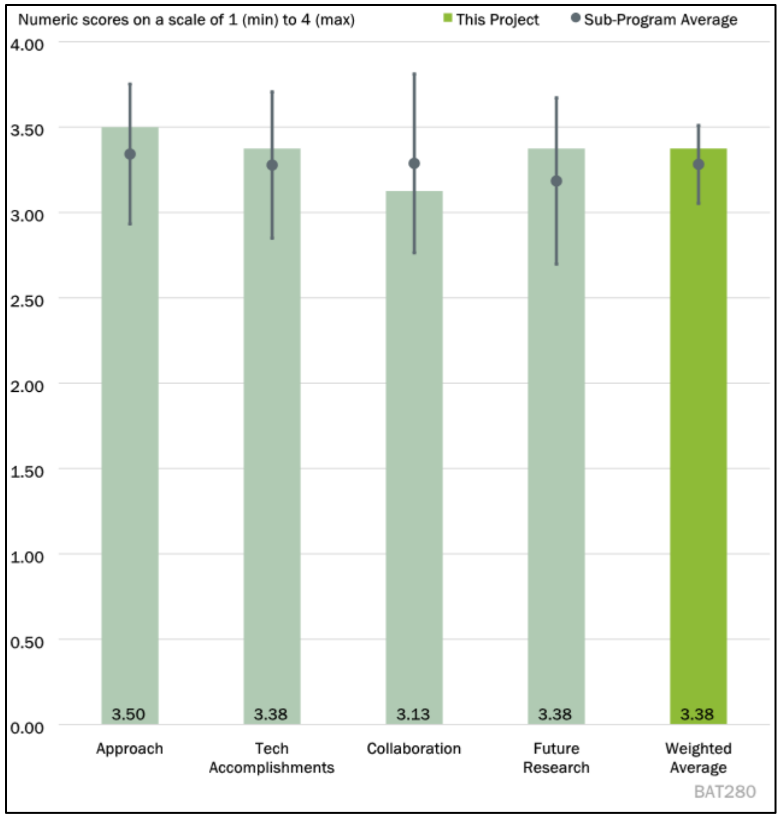

Figure 1-8 - Presentation Number: BAT280 Presentation Title: Novel Chemistry: Lithium-Selenium and Selenium-Sulfur Couple Principal Investigator: Khalil Amine (Argonne National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer expressed a favorable view of the project, emphasizing that it addresses technical barriers well. The results demonstrate notable progress in overcoming the challenges of decreased capacity upon increased sulfur loading. The novel Se-doped-S macroporous carbon cathode, which allows for an impressive 80% sulfur loading, stands out. Furthermore, pairing this cathode with a fluorinated electrolyte successfully addresses the issue of cycling performance, especially under low electrolyte-to-sulfur (E/S) ratios.

Reviewer 2:

The reviewer commended the organization of the project for its focus on enhancing the cycle life of Li-S cells. The incorporation of Se in sulfur improves electrical conductivity and increases active material loading. This Se doping strategy is not entirely new, as pointed out by the reviewer. Other strategies, such as modifying carbon pore structure and optimizing electrolyte formulation, are crucial to minimize polysulfide dissolution and shuttle. The *in operando* spectroscopic study will provide insights into current distribution and shuttle effects. The project's alignment with DOE goals is clear, emphasizing higher energy, longer life, and reduced cost for EV batteries. However, there are areas for improvement, notably in demonstrating more impressive performance at the cell level with relevant cathode loading and E/S and in enhancing cycle life.

Reviewer 3:

The reviewer highly appreciated the team's comprehensive approach to addressing the challenges of Li-S batteries. They have systematically tackled barriers such as the polysulfide shuttle effect, low electronic conductivity, low active material loading, Li dendrite formation, safety concerns, and limited cycle life. Their multifaceted approach includes Se doping for improved conductivity, examination of carbon pore structure's impact, development of innovative electrolytes, deployment of *in-operando* synchrotron X-ray and spectroscopy probes and leveraging advanced modeling capabilities.

Reviewer 4:

The reviewer felt the project's emphasis on developing innovative SSe cathode materials for Li-S batteries is timely. The results have shown that doping Se into S provides multiple advantages. However, the performance, in terms of areal capacity, seems comparable to existing literature and might not stand out as state of the art. The use of fluorinated ether (HFE), although beneficial, might lead to regulatory challenges. Furthermore, the topic of performance at higher rates has not been adequately addressed.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer observed that the team had made significant progress in achieving their technical goals and presented commendable results. When compared to the preliminary results showcased at the start of their poster, the team's current achievements were promising. Particularly noteworthy were the diagnostic tools they developed. An example was the heterogeneity map, which highlighted the irregular distribution of sulfur (S) and lithium sulfide (Li_2S) in the cell. Such a tool and its resultant data could offer insights into refining cell designs as well as understanding the kinetics and mechanisms of the overarching reactions at the electrode.

Reviewer 2:

The reviewer noted that there was substantial progress in enhancing performance when doping selenium (Se) onto S. Undoped S exhibited notable heterogeneity that led to elevated impedance and suboptimal sulfur utilization. In contrast, Se-doped S demonstrated a consistent S/Li_2S distribution in an organized macroporous carbon cathode with increased sulfur loading. This consistency also decreased polysulfide, as evidenced by *in operando* synchrotron studies. When the electrolytes were further modified by incorporating HFE into the solvent blend, both the cycle life and self-discharge showed improvement in coin cells and pouch cells, especially under high S loading and a diminished E/S ratio. Nevertheless, there were weaknesses identified by the reviewer: (1) While there was undeniable improvement in cycle life even at average sulfur loading levels, the E/S values, particularly in the pouch cells on Slide 12 (E/S: 7.5-10), were exceedingly high, rendering them impractical for genuine cell applications; (2) Slide 11 lacked E/S data; and (3) Reporting specific energy based solely on active material was both incomplete and potentially misleading. In summary, the improvements to cycle life were only slight, suggesting that the exact failure modes remained unidentified, possibly due to a polysulfide shuttle mechanism.

Reviewer 3:

The reviewer highlighted that the team had made several significant advancements in the project. In summary, these included the development of a 1 Ah Li-S pouch cell with an energy density exceeding 300 Wh/kg and a consistent cycle life, cell diagnostics that revealed failure mechanisms at low E/S ratios, the creation of an innovative selenium sulfide (SeS) cathode with an areal capacity surpassing 4 mAh/cm^2 for 100 cycles, and a comprehensive examination of the interface and polysulfide dissolution using time-of-flight secondary ion mass spectrometry (ToF SIMS) and *in situ* X-ray diffraction/X-ray absorption spectroscopy (XRD/XAS). Specific technical accomplishments comprised the fabrication and testing of a 350 Wh/kg Li-S pouch cell at a low E/S ratio of 2.5 ml/mg, uncovering the reaction heterogeneity of Li-S batteries in the Li-S pouch cell via synchrotron X-ray Diffraction (XRD) mapping, electrochemical impedance spectroscopy (EIS) analysis of Li/S batteries under high S loading and sparse electrolytes, and the design and synthesis of a Se-doped S/ordered macroporous carbon composite. Further, the combination of the cathode and HFE electrolytes showcased improved cycling stability and self-discharge. There was also a demonstration of effective cycling stability in practical pouch cells utilizing the new sulfur cathode and HFE electrolytes at reduced E/S ratios. Other accomplishments included the suppression of the shuttle effect, enhanced reaction reversibility through a cathode electrolyte synergy, and a maintained homogeneous S and Se distribution in cycled S cathodes due to the inhibited shuttle effect, thereby augmenting the interface stability of the cycled SeS cathode and Li metal anode.

Reviewer 4:

The reviewer stated that, while promising, the results to date did not surpass findings documented in cutting-edge literature, with an areal capacity below 6 mAh/cm^2. Additionally, the application of HFE could potentially introduce regulatory challenges, particularly if the use of fluoride compounds was prohibited. Furthermore, the cell's performance at elevated rates was not addressed. The reviewer also inquired about the volumetric energy density of the cells.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer noted that the project displayed commendable collaboration, especially within ANL and its various teams. However, expanding this collaboration to include other laboratories or universities would be beneficial.

Reviewer 2:

The reviewer noted ongoing collaborations with scientists from ANL. These primarily centered on characterization and understanding sulfur utilization, as well as the polysulfide shuttle mechanism through *in operando* studies. Weaknesses identified by the reviewer included a lack of collaboration with any external B500 team members. Collaborative efforts with institutions such as Idaho National Laboratory (INL) or the project's industrial partner could provide a more rigorous evaluation of selenium-sulfur (Se-S) cathodes.

Reviewer 3:

The reviewer stated the team's collaboration network was impressive. It included partnerships with Dr. C.J. Sun from the Advanced Photon Source (APS) at ANL, who provided expertise in X-ray absorption spectroscopy to understand mechanisms during charge/discharge cycles. Collaborations also extended to Dr. W. Xu and T. Li from APS at ANL, focusing on Synchrotron X-ray characterization of the crystal structure of S_xSe_y cathodes and their phase transitions during charge/discharge. Furthermore, Dr. Z. Yang from the Chemical Sciences and Engineering division at ANL contributed to X-ray photoelectron spectroscopy (XPS) for characterizing the cycled S cathode and Li metal anode. Dr. L. Cheng from the Materials Science Division at ANL provided computational modeling expertise, particularly regarding interactions between polysulfides and host materials.

Reviewer 4:

The reviewer commended the synergistic and complementary efforts demonstrated across the team.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer observed that the project had a clearly defined roadmap for upcoming endeavors. The team aspired to reach a lower E/S ratio (targeting an E/S of less than 2) and increase areal sulfur (S) loading. Present results indicated that the team was progressively advancing toward these objectives. Additionally, there was a plan in place to confront the reaction heterogeneity at the cell level to ensure extended cycle life.

Reviewer 2:

The reviewer stated the proposed future research, which encompassed the development of an interlayer design to diminish polysulfide crossover and the introduction of new electrolytes and electrolyte additives to enhance sulfur homogeneity in cathodes with elevated sulfur loading and diminished electrolyte content (aiming for an E/S close to zero), was seen as beneficial. Such efforts could pave the way for high-energy, long-cycle-life Li-S batteries. The reviewer emphasized the importance of optimizing the selenium (Se) content in the selenium-sulfur (Se-S) cathode to find the optimal balance for achieving a satisfactory cycle life. Modeling endeavors would be employed to support experimental research, ensuring a comprehensive understanding of outcomes. A weakness noted by the reviewer was that the upcoming year's investigations should prioritize showcasing the Se-S cathode in pouch cells with a low E/S, potentially in collaboration with an industry partner. Given the project's duration and significant funding, it was crucial to realize tangible outcomes and benefits.

Reviewer 3:

The reviewer identified challenges identified such as: sulfur utilization under low E/S ratios (2 ml/mg) and elevated areal S loadings (6 mg/cm^2), which currently inhibit the cell energy density of Li-S pouch cells (aiming for 500 Wh/kg). Furthermore, reaction heterogeneity at the cell level was pinpointed as a critical hurdle for achieving prolonged cycle life, and stabilizing Li metal at high current densities was still a challenge, constraining rapid charging capabilities of Li-S pouch cells. The proposed future endeavors were structured to tackle several persistent challenges. These included optimizing the Se ratio in the SeS cathode to boost capacity and voltage retention at higher current densities, designing innovative interlayers to support cycling of high-loading (more than or equal to 5 mg/cm^2) Li/S batteries at elevated current densities, introducing interlayers that would accommodate both high-energy and extended-cycle-life Li-S batteries, and devising electrolytes and additives to address reaction heterogeneity in scenarios of high S loading and lean electrolytes.

Reviewer 4:

The reviewer pointed out certain potential issues: employing interlayers might not be the optimal approach, especially when considering the volumetric energy density.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer asserted that the project aligned with and supported the overarching goals of the VTO and its Batteries subprogram. The project's exploration into Li-S batteries held the potential of delivering high energy densities (500 Wh/kg) at reduced costs, making it suitable for EVs and other energy storage applications.

Reviewer 2:

The reviewer believed the project upheld DOE objectives by developing advanced Li-S cells that offered greater specific energy, diminished costs, augmented safety, and superior cycle life when compared to LIBs. The challenge of harnessing Li-S technology with liquid electrolytes was well-documented, with past studies by the B500 teams not yet identifying a viable route. This particular project's emphasis was on curbing the polysulfide shuttle effect and augmenting the cycle life of the sulfur cathode using selenium (Se) doping. In essence, the project was in sync with the objectives and aims of the DOE VTO Batteries subprogram.

Reviewer 3:

The reviewer noted the project's intent was to surmount various obstacles associated with implementing Li-S in the energy storage domain. These challenges included the shuttle effect, reduced electronic conductivity, inadequate active material loading, Li dendrite formation, safety concerns, and insufficient cycle life.

Reviewer 4:

The reviewer affirmed the project's merit, emphasizing its potential to achieve the targeted energy density of 500 Wh/kg.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer acknowledged that resources allocated to the project were ample for meeting the specified milestones.

Reviewer 2:

The reviewer stated that the resources designated for the entirety of the project were deemed congruent with its scope, ensuring the successful attainment of the targeted milestones.

Reviewer 3:

The reviewer noted that the funding was seen as proportional to the project's scope, and the advancements and discoveries made thus far were noteworthy.

Reviewer 4:

The reviewer believed that the resources furnished for the project appeared fitting.

Presentation Number: BAT285
Presentation Title: Investigation of Sulfur Reaction Mechanisms
Principal Investigator: Deyang Qu (University of Wisconsin at Milwaukee)

Presenter

Enyuan Hu, Brookhaven National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 60% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 40% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

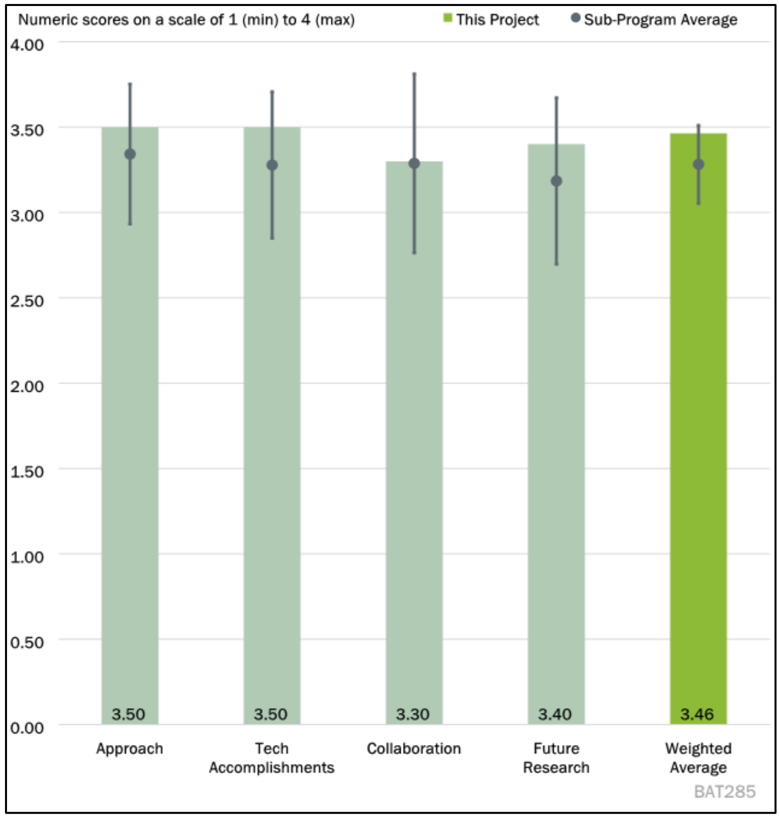

Figure 1-9 - Presentation Number: BAT285 Presentation Title: Investigation of Sulfur Reaction Mechanisms Principal Investigator: Deyang Qu (University of Wisconsin at Milwaukee)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer recognized that the research team employed a comprehensive array of techniques to prepare and analyze Li-S anode and cathode materials, notably the Li_xSi anode and sulfur-hosting carbon, which exhibited high absorption and catalytic capacities. The team also constructed and assessed all-solid-state Li-S batteries, utilizing *in situ* HPLC-MS-electrochemical methodology to monitor soluble polysulfides. *Ex situ* XRD and XPS were employed to inspect the surface characteristics of the sulfur cathode and Li anode.

Reviewer 2:

The reviewer commended the team for their exemplary efforts in tackling challenges. Specifically, they synthesized an organo-sulfur cathode material using thiuram polysulfides (PMTH) combined with a SSE. Even though these materials were susceptible to air and moisture, they effectively tackled polysulfide dissolution. The team's methods, such as using pre-lithiated Si via a mechanochemical process and the P-5 mechanical mill, were noted. The reviewer also drew attention to specific performance data and sought clarification on several aspects, including reasons for rapid fade, potential Si-related losses, and anode loading specifics.

Reviewer 3:

The team delineated eight strategic approaches, encompassing a range of topics from material selection to advanced characterization methods and extended collaborations. The project's focus on creating an all-solid-state Li-S battery, paired with *ex situ* and *in situ* investigation methodologies, was viewed as instrumental in deciphering sulfur-sulfur reaction mechanisms. Such insights are critical for refining and enhancing battery performance. The reviewer praised the team's innovative strategies for addressing issues like volume changes and stack pressure, common in Li-S SSBs.

Reviewer 4:

While acknowledging that the technical barriers were being addressed appropriately within the project's scope, the reviewer suggested emphasizing rate capability in forthcoming endeavors.

Reviewer 5:

The project's synthesis of advanced *in situ* characterization techniques with innovative material design was viewed positively, especially in advancing sulfur utilization and enhancing the cycling stability of all-solid-state Li-S batteries. The structured approach and well-organized plan of the project were appreciated by the reviewer.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer observed that the fully synthesized lithiated Si powder exhibited superior performance and cyclability compared to Li-In. The *in situ* electrochemical high-performance liquid chromatography-mass spectrometry (HPLC-MS) tool provided a deeper understanding of the Li-S redox reaction mechanism. It was found that long-chain dissolved polysulfide ions were the primary cause of the shuttle effect. The sulfur-hosting carbon, with high absorption and catalytic activity, was able to disproportionate long-chain polysulfide ions to form elemental sulfur and short-chain polysulfide ions. A reduced presence of dissolved long-chain polysulfide enhanced the cycling performance of the Li-S cell. Regarding the statement, "Thiuram polysulfide cathode showed good reversible volume changes," the reviewer suggested that it would be more informative to compare the volume/pressure changes of the thiuram polysulfide cathode with a benchmark cathode material.

Reviewer 2:

The reviewer acknowledged the team's outstanding technical achievements. Questions for the team included the following: The pre-lithiated Si was presented as the anode with the PMTH cathode and SSE. Given its impressive performance, the reviewer sought clarification on certain aspects. During the pressure measurements while cycling the Li_xSi against lithium titanate, why was not the pressure decrease at the end of the discharge and charge cycle consistent across all cycles? Why did the pressure not return to its initial level? It was understood that the pressure resulted from the expansion and contraction of the pre-lithiated Si. The reviewer hypothesized potential irreversible loss as a cause and inquired if this might be the reason for the observed stress change variation. Additionally, insights were sought on the correlation between pressure changes and changes in coulombic efficiency (CE) and capacity loss. With regard to the dual-function carbon host, the reviewer asked about the nitrogen content in the carbon samples NC750, NC800, NC900, and NC950. The reviewer suggested clarifying the reference to powdered activated carbon (PWA) as well as the ratio of polysulfides to the NC carbons during HPLC. If polysulfides were trapped by the NC carbons, was nitrogen responsible for trapping them? The reviewer also inquired about the dual role of the carbons and where disproportionation occurred – specifically, if it happened at the nitrogen site. If the NC carbons effectively trapped the polysulfides, what caused the initial decrease in capacity for the pouch cells?

Reviewer 3:

The reviewer enumerated seven notable technical accomplishments:

A dual-functional carbon was synthesized, exhibiting high sulfur/polysulfide absorption and catalytic activity. This facilitated the disproportionation reaction, converting long-chain polysulfides to short-chain polysulfides and elemental sulfur.

The *in situ* electrochemical HPLC/MS enhanced the understanding of the Li-S redox reaction mechanism.

It was confirmed that the shuttle effect could be mitigated using the dual-functional carbon by promoting the formation of short-chain polysulfide ions.

An organo-sulfur cathode, promising in terms of energy density and cyclability, was chosen for all solid-state Li-S batteries.

The PI's laboratory developed a method to synthesize fully lithiated Si powder. This powder, when paired with a sulfur cathode in an all-solid-state cell, performed well.

The team showcased a high sulfur cathode loading (17 mg/cm2) for an all-solid-state cell.

Advanced synchrotron-based spectroscopic and microscopic studies provided insights into the structures of polysulfide and polymer sulfur. This research also revealed the distribution of organic and inorganic species on the anode interface.

Given the provided funding and the project's timeline (which began on Oct. 1, 2022), the reviewer commended the significant technical progress achieved.

Reviewer 4:

The reviewer stated that, within the program's scope, the technical accomplishments were commendable.

Reviewer 5:

The reviewer praised the team for making significant progress in the past year, successfully meeting set milestones:

A dual-functional carbon was synthesized, demonstrating high sulfur/polysulfide absorption and catalytic activity. This enabled the disproportionation reaction, converting long-chain polysulfides to their short-chain counterparts and elemental sulfur.

The Li-S redox reaction mechanism was better understood due to *in situ* electrochemical mass spectrometry (MS) studies.

A small organo-sulfur compound, exhibiting the highest energy density in its class, was selected for use in an all-SSB.

The team showcased an all-SSB with high active loading (17 mg/cm2), demonstrating commendable cycle life.

A quality fully lithiated Li_xSi was synthesized and, when tested in an all-solid-state Li-S cell, yielded impressive performance.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer noted that the project team comprised a substantial number of collaborators, each bringing distinct research expertise. The University of Washington, Seattle, was responsible for the synthesis of SSEs. Cornell University took charge of organic material synthesis. Pacific Northwest National Laboratory (PNNL) focused on material synthesis and cell configuration. Lastly, Millipore Aldrich contributed organic cathode materials.

Reviewer 2:

While the reviewer acknowledged the team's effective collaboration with four distinct organizations, they expressed concerns about the lack of detailed information. The University of Washington, Seattle, was identified as providing the SSE, yet the specific system and collaborators involved remained unspecified. Similarly, Cornell University's contribution to organic material synthesis lacked specific details and names of team members. The contributions of PNNL and Millipore Aldrich, too, were vaguely described. With regard to Millipore Aldrich's involvement, the reviewer inquired if materials were simply purchased from Aldrich and sought clarification on the nature of the collaboration.

Reviewer 3:

The reviewer stated the roles of the collaborators were as follows:

University of Washington, Seattle: Synthesis of SSEs.

Cornell University: Organic material synthesis.

PNNL: Material synthesis and cell configuration.

Millipore Aldrich: Provision of organic cathode materials.

The reviewer found the milestones, approach, and project objectives to be well-articulated. However, the specifics of collaboration and individual responsibilities were ambiguous. Slide 14 provided a succinct overview of each collaborator's duties, yet there was a lack of discussion regarding the progress achieved by each entity. As a result, the reviewer had to base their evaluation on the collective technical progress of the project.

Reviewer 4:

The reviewer observed that the project reflected a collaborative team effort with clear task delegation.

Reviewer 5:

The project successfully engaged multiple PIs from both national laboratories and universities and incorporated several external partners from academia and industry. The reviewer commended the team for effectively leveraging the diverse expertise within the project to address technical challenges.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer found the outlined future research plans to be generally sound. However, there was some uncertainty regarding the strategy to "prevent dendrite growth and limit 'dead' Li formation." Although the approach section referred to the use of "*in situ* 3D microscopy and electrochemical measurements for dendrite detection during cell operation," the poster failed to present any findings on dendrite detection or strategies being employed to counteract it.

Reviewer 2:

The reviewer believed the future plan was pertinent. Yet, the strategy for exploring alternative dual functional carbon materials to mitigate the shuttle effect remained ambiguous. Given the different NC carbons displayed in the presentation, the changes the team aimed to make—whether adjusting N contents, adding different additives, or others—were not explicitly conveyed. There were also uncertainties surrounding the development of cathode architecture for optimizing the utilization of elemental sulfur and organo sulfur materials. The reviewer inquired about the specific architectural changes and questioned the intent behind enhancing collaborative research with academic institutions. Moreover, a potential hurdle identified was the presence of dendrites in the anode. The project's usage of pre-lithiated Si posed its own set of challenges. Should they switch to the NC carbon for the Li-S system, it would revert to Li metal. The reviewer sought clarity on the proposed strategy to combat dendrite formation in the upcoming research.

Reviewer 3:

For the 2023 research agenda, the reviewer listed:

Conducting a comprehensive interfacial study of both small organo-sulfur and surface-protected Li with SSE: Excellent.

Completing full cell tests with selected small organo-sulfur, surface-protected Li anode, and SSE: Excellent.

Thorough investigation of polysulfides in a solid phase: Excellent.

For 2024, the agenda comprised:

Gaining a deeper understanding of the catalytic behavior of polysulfide disproportionation using *in situ* electrochemical HPLC-MS: Excellent.

Probing alternative dual functional carbon materials to counteract the shuttle effect: Good — though exploration is commendable, an emphasis on refining the existing dual functional cathode might prove beneficial.

Designing a cathode architecture tailored to the effective utilization of elemental sulfur and organo sulfur materials: Excellent — a focus on decreasing stack pressure during battery cycling is advisable.

Fabricating multi-layer pouch cells using sulfur or organo sulfide cathodes: Excellent.

Persisting in refining the S electrode production method to augment sulfur loading and devising techniques to create thick sulfur cathodes: Excellent.

Intensifying collaboration with academic institutions and industry counterparts: Satisfactory — partnering with a SSE material or battery company for cell testing and validation might be beneficial.

Reviewer 4:

From a foundational understanding, the reviewer deemed the future research direction as fitting. The reviewer suggested that a heightened emphasis on addressing the rate capability could bolster the project’s practical implications.

Reviewer 5:

The reviewer acknowledged that the project delineated distinct tasks for upcoming research. This included advanced characterization, crafting advanced carbon materials and cathode structures, dry cathode processing, and devising multi-layer pouch cells. Such efforts could potentially overcome the challenges inherent to all-solid-state Li-S batteries.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer noted that the synthesis and characterization of anode, cathode, and electrolyte materials for Li-S batteries aligned seamlessly with the BAT program’s objective of fostering high-energy rechargeable battery innovation. The fruition of this project would significantly propel the advancement of state-of-the-art Li-S batteries.

Reviewer 2:

The reviewer affirmed the project’s relevance to VTO’s ambitions. The pursuit of an all-solid-state Li-S battery was especially pertinent. Likewise, the exploration of alternative sulfur cathodes, exemplified by the organo sulfur cathode, was both innovative and beneficial. Devising strategies to inhibit dendrite growth was deemed crucial.

Reviewer 3:

The reviewer believed that this project was in harmony with the overarching objectives of the VTO subprogram. The initiative sought to pioneer new cathode and anode materials with the aim to enhance the energy density and longevity of all-solid-state Li-S batteries. Concurrently, *ex situ* and *in situ* investigative techniques were employed to gain a comprehensive understanding of sulfur-sulfur reaction mechanisms. Such insights would be instrumental in refining SSB materials.

Reviewer 4:

The reviewer highlighted the program's commitment to advancing materials designed for energy storage. These materials, not only being abundant, held the promise of transcending the existing technological benchmarks in energy storage.

Reviewer 5:

The reviewer stated the project was strategically geared towards crafting high-energy, cost-effective all-solid-state Li-S batteries. Such advancements could alleviate the limitations inherent to contemporary LIBs in relation to energy density, cost-efficiency, safety, and supply chain vulnerabilities. The reviewer emphasized that this direction was congruent with VTO's vision of spearheading battery innovations catering to the escalating demands of automotive applications.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer observed that the research teams had the advantage of state-of-the-art facilities and had innovated distinct research devices and capabilities. Collaborative efforts among the team members efficiently utilized these facilities, thereby accelerating the pace of research.

Reviewer 2:

The reviewer acknowledged the ample resources shared between Brookhaven National Lab and the University of Milwaukee. Such resources were deemed sufficient to undertake the proposed tasks. Consequently, the reviewer anticipated that the project would achieve its milestones.

Reviewer 3:

The reviewer affirmed that the allocated resources for the project were adequate to realize the stated milestones within the proposed timeframe.

Reviewer 4:

The reviewer inferred from the project's performance that the resources had been satisfactory in meeting the program's milestones.

Reviewer 5:

The reviewer noted that the project was a collaboration of multiple PIs spanning national laboratories, universities, and several external academic and industrial partners. Together, they pooled resources focused on material synthesis, advanced characterization, and cell testing pertinent to the proposed tasks.

Presentation Number: BAT315
Presentation Title: Process R&D for Droplet-Produced Powdered Materials
Principal Investigator: Joe Libera (Argonne National Laboratory)

Presenter

Joe Libera, Argonne National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

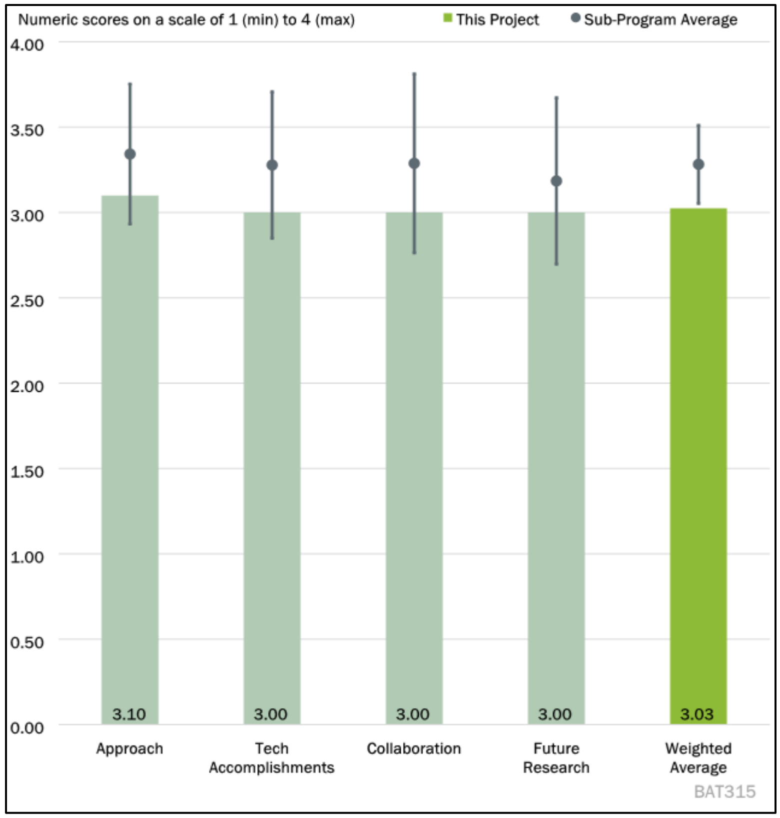

Figure 1-10 - Presentation Number: BAT315 Presentation Title: Process R&D for Droplet-Produced Powdered Materials Principal Investigator: Joe Libera (Argonne National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer recognized that flame spray pyrolysis (FSP) and related aerosol methods were prevalent and economical industrial techniques for synthesizing functional materials. When these techniques were integrated into battery material studies, the adaptability of their control parameters potentially facilitated new material synthesis pathways and the generation of materials unattainable via other techniques. Unlike conventional methods like sol-gel or co-precipitation that often require multiple stages, FSP offers a one-step production. Additionally, it can yield nanoscale or amorphous formatted, atomistically mixed precursors that set the stage for subsequent heat processing reactions. The reviewer believed that incorporating FSP into VTO's toolkit for materials synthesis and processing was a strategic move to propel advancements in vehicle battery technology.

Reviewer 2:

The reviewer found that the technical barriers were not thoroughly addressed. The term "'Life' barrier" appeared ambiguous. However, the project was meticulously planned, emphasizing aerosol synthesis for scalability. Moreover, maintaining close ties with the industry ensured that the project remained aligned with the evolving requirements.

Reviewer 3:

The reviewer noted that the cathode materials presented were not representative of the current or upcoming generation. Majority of the introduced materials did not seem poised for widespread market adoption.

Reviewer 4:

The reviewer commended the PIs for pioneering a method focused on powder creation to derive CAMs.

Reviewer 5:

The project's objective, as understood by the reviewer, was to tackle the cost, lifespan, and energy aspects of LIB electrode materials by innovating the manufacturing process. The team opted to create powders using aerosol procedures to derive CAMs, solid electrolytes, additive particles for lifespan extension, and filler particles for polymer composites. While the team had successfully advanced its experimental capabilities, the materials' performance did not measure up to the current leading materials. The project's ambitious timeline and the inclusion of a broad spectrum of materials, each demanding unique synthesis conditions, raised concerns for the reviewer about the potential dilution of efforts.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer stated that the team completed the facility's construction for a 500 g/hour production and developed *in situ* real-time UV-Raman monitoring capability. Subsequently, the facility was utilized to demonstrate the FSP synthesis of several battery-related materials. Among these, the synthesis of LT-NMC111 via FSP stands out as particularly interesting, as it utilizes a precursor with atomic mixing and rapid quenching, uniquely enabled by FSP. This approach may extend to other NMC materials.

Reviewer 2:

The reviewer stated that the FSP system has been developed at the progressive production scale of 500 g/hour. The addition of the Framework for Self-Driving reactor operation and UV-Raman real-time diagnostic system represents a step closer to industrial manufacturing and is open for further improvement. The reviewer recommended implementing an auto-detection mechanism for abnormalities in real-time UV-Raman diagnostic characterization to handle the large amount of data in real time. FSP and solution precipitation (SP) have been used to produce various active materials, proving their capability to synthesize specific materials that are difficult to achieve otherwise, such as $LiCo_{0.8}Al_{0.2}O_2$ and the spinel/layer composite LT-NMC111. These are unique chemistry systems that can offer additional insights into new strategies for improving CAM quality at the lowest cost.

Reviewer 3:

The reviewer remarked that the project's overall objective does not appear to align with the DOE Vehicle Technologies Office (VTO) goals. The cathode materials reported in this presentation are either high in Co or outdated for EV applications. Furthermore, the cycling performance of the synthesized cathode materials is subpar. XRD plots indicate peak broadening, suggesting a lack of crystallinity. The charge capacity for lithium cobalt aluminum oxide appears to be extremely low, even with such a high surface area material. The reviewer emphasized the need for a thorough investigation to understand the reasons for such poor performance. For FY 2022, all seems acceptable, but there is a lack of detailed information.

Reviewer 4:

The reviewer suggested that the team has synthesized several materials, but their performance is not optimized. The reviewer recommended that the team focuses on a small set of material compositions before expanding efforts to other compositions. The *in situ* Raman diagnostics, the reviewer praised, are particularly impressive.

Reviewer 5:

The reviewer commented that for FY 2022 everything seemed to be OK, but there are detailed pieces of information missing.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer suggested that the collaboration can be broadened by including other national laboratories with synchrotron and neutron facilities for *in situ* structural characterization of the heating process.

Reviewer 2:

The reviewer commented that as a team working as intermediaries between laboratory scale and pilot run of material synthesis, this is a well-rounded team with collaboration within ANL in software integration, with industry partner Cabot Corporation (Cabot Corp.), and the academic institution Purdue University.

Reviewer 3:

The reviewer noted that the team assembled for the project appears to be knowledgeable in the area of the proposed work.

Reviewer 4:

The reviewer pointed out that only collaborations with Cabot Corp. and Purdue University are indicated.

Reviewer 5:

The reviewer recommended that the team has adequate collaborations within the project team but also suggested having external collaborations, especially with experts specialized in conventional synthesis methods. The reviewer emphasized the importance of direct comparisons between the samples produced in this project and those produced by other methods.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer pointed out that there are numerous options for tuning the process parameters to accommodate different material syntheses. The project should concentrate on materials that are uniquely accessible via FSP and should seek more collaborators who can benefit from the products of the FSP facility.

Reviewer 2:

The reviewer observed that the purpose for future work has been clearly defined, and the targets are achievable within the proposed time frame. However, the reviewer suggested that a clearer plan could be achieved by taking negative factors into account. For example, a slower evaporation rate of the FSP system may address the high surface area issue, but on the other hand, it may also reduce the production rate.

Reviewer 3:

The reviewer commented that the proposed work appears to be more driven by academic curiosity than commercial value that could generate interest from cathode manufacturers. High voltage spinels currently lack a stable electrolyte, and disordered rock salt (DRX) is still a long way from creating commercial interest. The work to reduce surface area is considered critical, as it aligns well with commercial needs, particularly in achieving higher solid content in slurry.

Reviewer 4:

The reviewer noted that the proposed future research seems acceptable.

Reviewer 5:

The reviewer commended the team for creating a great facility for the manufacturing process and for providing a variety of different materials in terms of compositions and crystal structures. However, the reviewer suggested that the complexity could become overwhelming and recommended that the team should focus on specific areas. Additionally, the reviewer proposed that the team may consider including TEA and life-cycle analysis to evaluate the practical impact of their work.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer affirmed that the FSP facility, along with other materials synthesis and processing centers at ANL, such as the hydrothermal synthesis facility and the Materials Engineering Research Facility (MERF), will serve as a strong driving force in new materials discovery and the development of new synthesis protocols, both for laboratory and industrial-scale production.

Reviewer 2:

The reviewer pointed out that the project has demonstrated the potential for continuous high-volume production of various materials, including cathodes, solid electrolytes, and other components for battery production.

Reviewer 3:

With the integration of auto-reactor operation and *in situ* UV-Raman diagnostic characterization, the reviewer said the project has taken a significant step closer to pilot-scale material production in industrial manufacturing. The possibility of synthesizing unique chemistry systems through aerosol methods also broadens the path for improving CAMs.

Reviewer 4:

The reviewer emphasized the importance of alternative manufacturing methods for cathode materials and other battery materials in the context of domestic manufacturing. While the proposal aims for this, the reviewer expressed that the results are not particularly encouraging. The reviewer suggested that the team should focus on present or next-generation cathode or electrolyte materials that can help address some of the technoeconomic challenges in the field.

Reviewer 5:

The reviewer acknowledged that the project has direct relevance to the VTO subprogram objectives and is aligned with the overall goals of VTO programs. The successful outcome of the project, the reviewer affirmed, could be transformative.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that the project has sufficient resources for further development, but they may require intra-lab collaborations in machine learning (ML) optimization.

Reviewer 2:

The reviewer affirmed that the resources are adequate for a small team to achieve the stated accomplishments.

Reviewer 3:

The reviewer remarked that the team is well-suited for achieving the goals of this project.

Reviewer 4:

The reviewer concurred, stating that the resources are indeed sufficient.

Reviewer 5:

The reviewer observed that the team has developed ample resources, especially experimental apparatus, to perform the tasks, and suggested that some external experts may offer additional assistance.

Presentation Number: BAT360
Presentation Title: Scale-up, Optimization and Characterization of High-nickel Cathodes
Principal Investigator: Arumugam Manthiram (University of Texas at Austin)

Presenter

Arumugam Manthiram, University of Texas at Austin

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

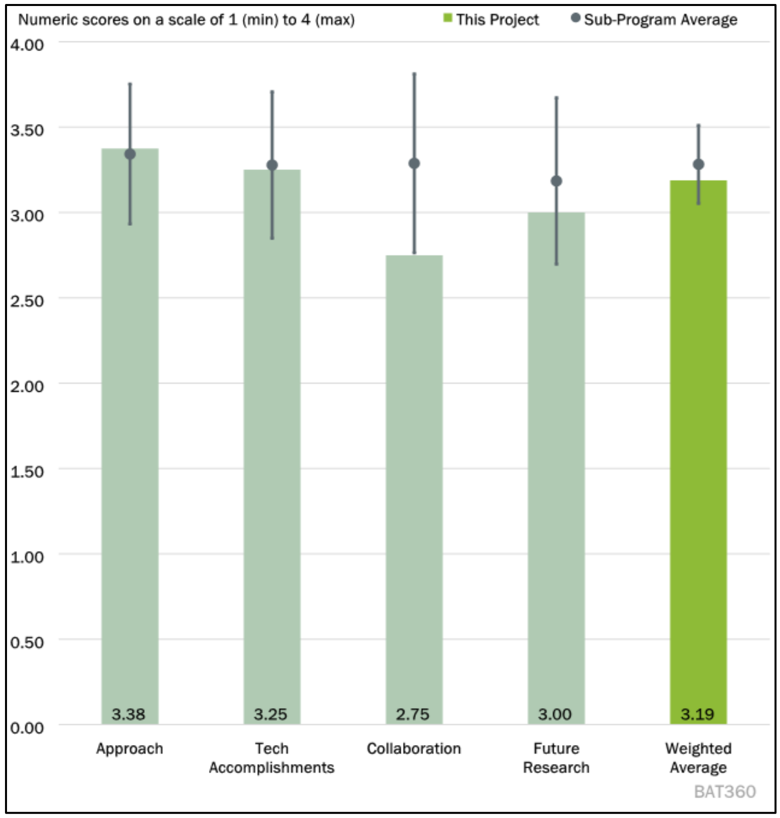

Figure 1-11 - Presentation Number: BAT360 Presentation Title: Scale-up, Optimization and Characterization of High-nickel Cathodes Principal Investigator: Arumugam Manthiram (University of Texas at Austin)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer commended the approach taken by Prof. Manthiram's group, noting its excellence. However, the reviewer also pointed out an extraordinarily broad scope in the project, which includes scale-up of high nickel (Ni) NMCs, Li_2S electrocatalyst, SSE development, liquid electrolyte optimization, and gas generation studies.

Reviewer 2:

The reviewer acknowledged that the team is effectively addressing a major technical barrier concerning a no-Co, high-energy-density cathode. Developing advanced electrolytes is considered a promising avenue for improving the high-voltage performance of high-nickel cathodes. The reviewer noted that, as is characteristic of Professor Manthiram's research, the work is conducted systematically and employs excellent diagnostic techniques to complement the investigation.

Reviewer 3:

The reviewer recognized the team's expertise in cathode materials synthesis and material characterizations. However, the reviewer expressed a concern regarding the project's title, which focuses on the scale-up and optimization of Ni-rich materials, while the presentation lacks relevant details in this regard.

Reviewer 4:

The reviewer questioned the purpose of repeating the work on NMC811, as previous knowledge indicated that the work on lithium solid electrolyte (LSE) had been done in a collaboration institute in previous years. The reviewer sought clarification on whether the intention is to establish a baseline at UT-Austin, which did not work on this before.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer noted that there is an impressive amount and quality of data presented.

Reviewer 2:

The reviewer expressed that the team has made outstanding progress over the past year, and this progress has been detailed in numerous reports, papers, and presentations. The reviewer highlighted that the team has effectively demonstrated the critical role of electrolyte stability in the performance of high-nickel cathodes, as well as the benefits of localized saturated electrolytes. However, the reviewer pointed out a potential inaccuracy in the reference on Slide 7, as the paper referred to $LiCoO_2$ and not NMC811.

Reviewer 3:

The reviewer acknowledged that the team has synthesized high-quality cathode materials and designed novel lithium solid electrolyte (LSE) electrolytes. The combination of Ni-rich cathodes and LSE electrolytes, in general, shows much-improved performance. However, the reviewer suggested that since the presentation focuses on the scale-up and optimization of Ni-rich materials, the team should provide more details about the cathodes themselves. Additionally, the reviewer recommended using a high-quality commercial Ni-rich NMC as a baseline to help the reviewer understand the advantages of the Ni-rich cathodes prepared by the team.

Reviewer 4:

The reviewer inquired about quantitative numbers for the in-house scale-up of the high Ni cathode, seeking information about the volume at which the scale-up currently stands. This information, the reviewer noted, would provide insight into the progress over time. The reviewer also expressed surprise that no structural information had been provided, given the numerous collaborators working on X-ray-related characterization. Structural data, the reviewer emphasized, is crucial for the reviewer to judge whether the right material has been synthesized.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer suggested that, given the excellent cycling results shown, increased collaboration with industry may be relevant.

Reviewer 2:

The reviewer pointed out that some of the R&D activities are being conducted by a capable team comprising members from national laboratories and academia. The reviewer noted that the PI mentioned collaboration with an industrial partner, General Motors (GM), in response to the reviewers' comments. The reviewer recommended that this collaboration and GM's specific contributions to the project should be explicitly noted in the presentation slides.

Reviewer 3:

The reviewer acknowledged that this is a highly collaborative team with diverse capabilities from each PI. However, the reviewer noted that the role of the industry partner is not always clear.

Reviewer 4:

The reviewer raised the concern that while many collaborators have been listed, their specific contributions are not clearly marked in the presentation. The reviewer emphasized that it is essential to highlight the specific contributions from these team members. Additionally, the reviewer noted that there were many collaborators working on synchrotron-related work, but no data was provided on the materials synthesized.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer recommended de-emphasizing research on high nickel (Ni) NMC materials, as the industry has made significant progress in commercializing these materials. The reviewer noted that while dopants for high voltage (V) stability are valuable, there may not be a substantial additional energy gain to be obtained in this area.

Reviewer 2:

The reviewer expressed concern about the milestones listed on Slide 4, specifically the ones related to developing a solid electrolyte for Li/S and fabricating Li_2S electrocatalysts. The reviewer indicated that these milestones appear to be out of touch with the project’s focus. In light of this, the reviewer suggested that the project should start investigating next-generation cathode materials and leave further refinement and analysis of transition metal oxide cathodes to the industry.

Reviewer 3:

The reviewer acknowledged that the future plan shifts from Ni-rich cathodes to Li-sulfur (Li-S) batteries, and the team has defined future tasks clearly. However, the reviewer recommended that the team clarify how they intend to transfer optimal electrolyte compositions from Ni-rich cathodes to Li-S batteries.

Reviewer 4:

The reviewer criticized the project’s approach, describing it as a “cook and look” approach with a conservative experimental design that lacks a comprehensive vision regarding the key parameters affecting electrolyte stability. The reviewer expressed concern that there is a lack of clarity and guidance in the project’s strategies for searching or designing electrolytes to address the key challenge.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer affirmed that the effort is highly relevant.

Reviewer 2:

The reviewer stated that this effort is relevant and will aid B500 in meeting its near-term goals, particularly in moving away from Co and developing a high energy density cell.

Reviewer 3:

The reviewer expressed that this is a very successful project and has the potential to help achieve the VTO objectives.

Reviewer 4:

The reviewer noted that the work is relevant to VTO's objective of achieving high energy density energy storage technologies.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer found the resources appropriate and considered the project to be an excellent value for the R&D investment.

Reviewer 2:

The reviewer noted that the team has access to the best resources in the United States, which enables them to successfully meet their project goals. However, the reviewer expressed difficulty in assessing the resources fully when the specific amount devoted to this project is not provided.

Reviewer 3:

The reviewer stated that the team possesses ample and appropriate experimental resources, which can be fully utilized and leveraged to their maximum potential, especially when collaborating with other entities.

Reviewer 4:

The reviewer observed that the project has involved numerous entities with various aspects of battery research and applications. The reviewer suggested that the PI should make efforts to involve these entities and encourage their contributions to the project.

Presentation Number: BAT362
Presentation Title: High Capacity S Cathode Materials
Principal Investigator: Prashant Kumta (University of Pittsburgh)

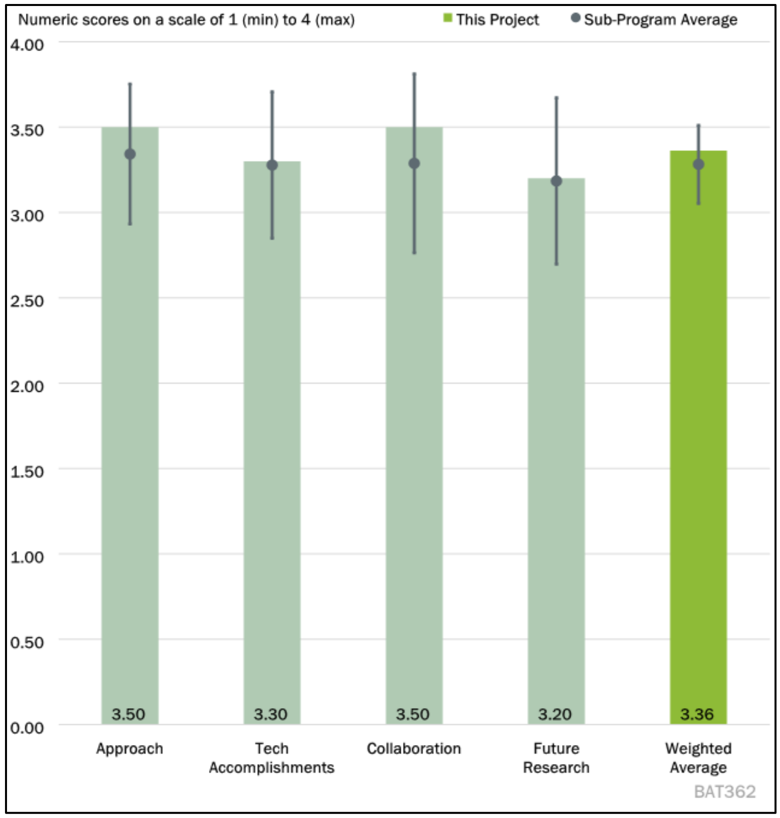

Figure 1-12 - Presentation Number: BAT362 Presentation Title: High Capacity S Cathode Materials Principal Investigator: Prashant Kumta (University of Pittsburgh)

Presenter

Prashant Kumta, University of Pittsburgh

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer found the project to have a reasonable approach to developing high-energy sulfur cathodes, especially in the context of the B500 program. The emphasis on achieving high loading (more than 5 mAh/cm^2) electrodes for EV cells was noted as a positive aspect.

Reviewer 2:

The reviewer pointed out that a carbonized PAN (polyacrylonitrile) fiber mat was used as a sulfur host material, eliminating the need for a binder. The project successfully demonstrated a high areal loading of sulfur in a coin cell. The reviewer emphasized that in addition to areal capacity, the density of the fiber mat and thus the volumetric capacity is also crucial.

Reviewer 3:

The reviewer commended the project team for accurately identifying technical barriers and having a well-planned timeline.

Reviewer 4:

The reviewer expressed several weaknesses and concerns:

The project’s progress is still far from the B500 goals after a year into the second phase.

Achieving 300 Wh/kg in subsequent pouch cells with the capacities and electrolyte content used is doubtful.

The cycle life target for the current year (100 cycles) may not be challenging enough compared to the ultimate goal of 1000 cycles.

Reviewer 5:

The reviewer provided a detailed overview of the project's alignment with the B500 program's general approach and goals, including breakthroughs in controlling electrochemical reactions, materials development, collaboration between national laboratories, universities, and industry, and achieving total control of battery chemistries for scalable technologies.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer expressed concern about the 600–800 mAh/g capacity shown on Slide 12 at C/10, noting that while it is better than NMC, it is not dramatically better. The reviewer pointed out that such high loadings tend to exhibit very high impedances, as evidenced by the 20% capacity drop when the rate is increased from C/20 to C/10.

Reviewer 2:

The reviewer noted that a fiber mat was successfully made, and sulfur was loaded into the mat. The electrode's performance was demonstrated in a coin cell, showing decent capacity and cycle life. However, with 53% porosity, the reviewer raised concerns about the density of the electrode and suggested investigating the rebound or bounce-back of the electrode after compression.

Reviewer 3:

Regarding the infusion of sulfur on conducting carbon and carbon fiber mat (CFM) substrates, the reviewer mentioned that the reported cell-specific energy on Slides 12 and 13 is not provided. Additionally, considering the high sulfur content (78%) in the cathode, the effectiveness of CFM in trapping polysulfide intermediates is unclear. The reviewer suggested conducting a volume ratio analysis for more insight.

Reviewer 4:

The reviewer acknowledged the good progress in developing directly generated sulfur architectures on conducting carbon and integrating them with suitable catalysts. High proportions of sulfur were infused into these carbon mats, leading to cathodes with high areal capacities (5–6.3 mAh/cm^2) and decent cycle life (80 cycles) with good capacity retention. However, the reviewer questioned why the cycling stopped at 80 cycles and inquired about the failure mode. The reviewer recommended testing these cathodes in multi-layer pouch cells under real lean electrolyte conditions (E/S less than 5) with a Li anode or preferably a Li alloy to understand their performance in terms of specific energy and cycle life.

Reviewer 5:

The reviewer noted that the technical progress is good and contributes to overcoming some barriers. However, the reviewer expressed concerns that the achieved performance levels are promising but not on par with program goals. The reviewer suggested focusing on demonstrating performance enhancements in pouch cells in parallel with material development to expedite technology implementation.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer noted that the PI collaborates with members of the B500 consortium, indicating good collaboration within the consortium.

Reviewer 2:

The reviewer stated that collaboration between the B500 consortium members appears to be very good.

Reviewer 3:

The reviewer observed that several B500 team members are listed as team members in this project and suggested that collaboration with these team members may be possible later as new cathode materials and binders are developed. However, the reviewer raised a weakness, noting that there appears to be no active collaboration with any of the team members specific to this project. The reviewer recommended considering collaboration with an industrial partner or a national laboratory (e.g., PNNL or INL) to demonstrate the materials in pouch cells in parallel with material development.

Reviewer 4:

The reviewer provided information about the project's affiliation with the B500 program and listed the collaborating entities, which include PNNL, Binghamton Univ., BNL, INL, GM, Penn State Univ., Stanford Univ./SLAC, Texas A&M, UC San Diego, Univ. of Maryland, Univ. of Pittsburgh, Univ. of Texas, Austin, and Univ. of Washington, as well as an industry advisory board team.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer commented positively on the proposed future work, particularly noting that it's essential to have means of evaluating sulfur (S) and electrolytes beyond cycle life testing in fundamental work on challenging chemistry.

Reviewer 2:

The reviewer mentioned that future plans will focus on the porous structure of the mat and potential catalyst investigation. However, the reviewer recommended that the PI demonstrate longer cycle life in full cells as part of the future work.

Reviewer 3:

Regarding the proposed future research on incorporating functional electrocatalysts, the reviewer found it to be a reasonable approach.

Reviewer 4:

The reviewer provided an overview of the well-laid-out plans for future studies, including developing new sulfur hosts and catalysts to improve the specific energy, kinetics, and cycle life of Li-S cells. However, the reviewer pointed out that the studies seem to continue focusing on material development and suggested that part of the effort should also focus on demonstrating the performance enhancements from these materials in pouch cells.

Reviewer 5:

The reviewer acknowledged that the team has identified and proposed detailed future work, including the identification of mesoporous ordered ceramics (MOCs) and porous organometallic framework materials (POFM) serving various functions in Li-S cells. The proposed studies were considered effective and valuable in addressing most of the barriers.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer emphasized the high relevance of sulfur (S) as a high-energy and EaCAM.

Reviewer 2:

The reviewer stated that the Li-S battery is highly relevant to the VTO objectives.

Reviewer 3:

The reviewer noted that this project aligns perfectly with the mission of the VTO Battery program, emphasizing that Li-S batteries hold great promise in addressing supply constraints associated with high nickel cathodes, making them highly relevant and significant for the program's objectives.

Reviewer 4:

The reviewer pointed out that the project supports the overall DOE objectives by developing advanced Li-S cells with higher specific energy, lower cost, enhanced safety, and improved cycle life compared to LIBs. The reviewer highlighted the focus on mitigating the polysulfide shuttle and improving cycle life with new sulfur hosts and catalysts, making the project relevant to the DOE VTO Batteries program objectives and goals.

Reviewer 5:

The reviewer mentioned that this project is an integrated part of the B500 program, with a specific focus on Li-S batteries.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer found the project's resources to be reasonable and commensurate with the scope of work.

Reviewer 2:

The reviewer noted that the PI and the B500 consortium have sufficient resources to support the research activities.

Reviewer 3:

The reviewer stated that the resources of the project appear to be sufficient.

Reviewer 4:

While the reviewer mentioned that the resources for the overall project seem commensurate with the scope and adequate to achieve the targeted milestones, the reviewer also noted that it is not clear how much is the allocation specifically for this project, as the numbers given are for the entire B500 program.

Reviewer 5:

The reviewer concluded by mentioning that the fund is comparable to the scope of work, and the progress and findings are significant.

Presentation Number: BAT367
Presentation Title: Multiscale Characterization Studies of Li Metal Batteries
Principal Investigator: Peter Khalifah (Brookhaven National Laboratory)

Presenter

Peter Khalifah, Brookhaven National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

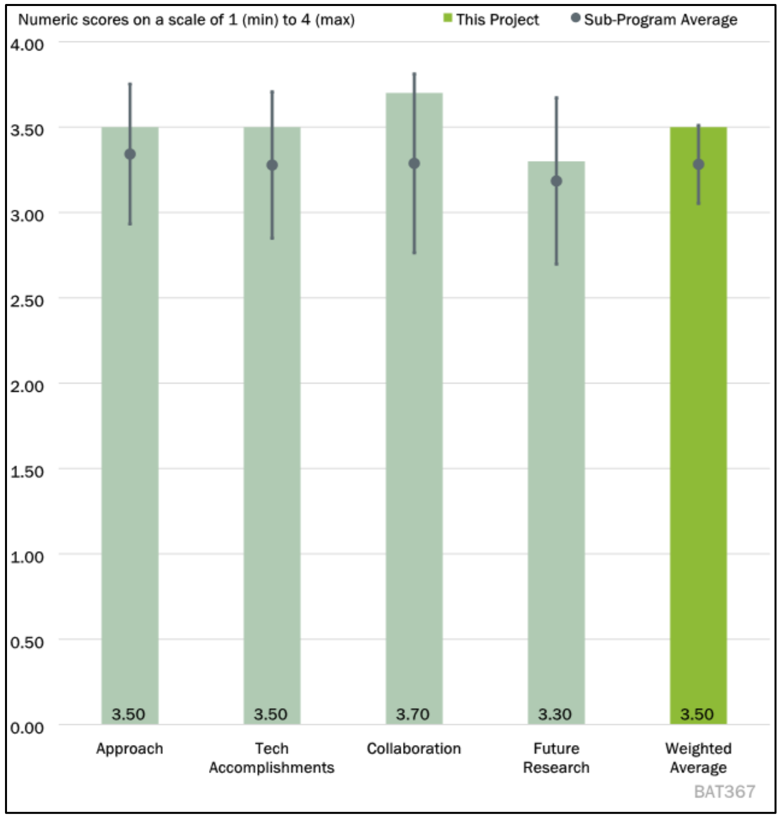

Figure 1-13 - Presentation Number: BAT367 Presentation Title: Multiscale Characterization Studies of Li Metal Batteries Principal Investigator: Peter Khalifah (Brookhaven National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer acknowledged the project's use of synchrotron X-ray diffraction for *operando* probes into the Li-S cell, solvent effects on polysulfides, and the components of the Li metal solid-electrolyte interface (SEI). The results were noted to effectively probe key battery components with superb sensitivity to light elements and were expected to characterize the SPAN cycling mechanism, sulfur polymorphism, and Li metal SEI evolution.

Reviewer 2:

The reviewer stated that the project's objective is to characterize battery materials and their electrochemical processes using synchrotron X-ray-based techniques. The project team was commended for making good use of the large user facilities at DOE laboratories and for employing their expertise in battery materials and synchrotron techniques developed over their long tenure of battery studies.

Reviewer 3:

The reviewer expressed some skepticism about the effectiveness of characterizing the SEI chemically and morphologically in solving critical issues in Li metal batteries. The reviewer mentioned that decades of papers on characterizing the SEI on graphite have contributed to understanding how certain additives work but may not have directly contributed to solving the problem. Industry was noted to have already solved the SEI-related problems a decade or two ago.

Reviewer 4:

Regarding the project's stated technical barrier of increasing the energy density of Li-ion cells, the reviewer noted that the approach seems to be more focused on understanding failure modes of materials used for high-energy batteries rather than directly increasing energy density. The reviewer pointed out that the project develops techniques to understand chemical speciation during cycling but questioned how these results would lead to changing the chemistry.

Reviewer 5:

The reviewer affirmed that the work is part of the larger B500 project and is well-integrated with the efforts within B500. The data obtained from the BNL sub-team was deemed valuable and timely, and it was expected to aid the broader B500 team in understanding the internal processes of cells when varying electrolytes, among other factors.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer noted the completion of speciation studies in Li-S pouch cells, quantification of transition metal cross-over amounts, and the investigation of the solid-electrolyte interface (SEI) of Li metal anodes.

Reviewer 2:

The reviewer commented the project's research accomplishments were primarily focused on Li-S pouch cell batteries and Li-metal anodes in NMC coin cells. The reviewer acknowledged that the project team had made discoveries that could advance understanding of the SPAN reaction mechanism and Li-metal SEI. However, the reviewer suggested that the team should further develop these findings into electrochemical insights and utilize the knowledge to improve battery performance. The reviewer posed questions about the origin and implications of inhomogeneities in the degree and rate of phase transition in charge products in Li-S batteries and how this phenomenon relates to capacity retention.

Reviewer 3:

The reviewer praised the technical work as excellent but expressed a preference for the work to be aimed at understanding how things work and fail, rather than focusing solely on characterization. The reviewer suggested exploring whether SEI films with specific morphologies or chemical compositions are more durable than others and how insights in sulfur battery chemistry can improve approaches to solving problems.

Reviewer 4:

The reviewer provided detailed information about the accomplishments related to synchrotron diffraction, the detection of polysulfides, transition metal dissolution, and the presence of LiH on the surface of Li. These techniques were considered unique and valuable for understanding the failure modes of Li/S and Li/NMC cells and the impact of electrolyte composition.

Reviewer 5:

The reviewer mentioned that it was not entirely clear from the limited information in the slides how far the interpretation of the data extended. For instance, the data on transition metal dissolution was presented, but the presentation did not provide significant insight into why manganese (Mn) is more likely to dissolve. The reviewer acknowledged the progress as significant, with real findings that have had an impact, describing the effort as very solid.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer highlighted the strong collaborative efforts within the team, particularly between Stony Brook and BNL in the current period. The collaboration was described as well-coordinated.

Reviewer 2:

The reviewer also noted the extensive collaboration within the B500 consortium, which includes national laboratories, universities, and industrial companies. The roles of each institute within the consortium were well-defined, indicating a high level of organization.

Reviewer 3:

While acknowledging the excellence of the collaboration, the reviewer suggested that the team could benefit from the involvement of theorists who could work on leveraging the new information.

Reviewer 4:

The reviewer observed that despite being from a university, one team member appeared to be collaborating with several members of the consortium to help them understand why their specific components were not performing well.

Reviewer 5:

Overall, the reviewer praised the collaboration between BNL and the rest of the B500 team, highlighting the importance of the questions being addressed at the synchrotron and their strong integration with the broader goals of the B500 project. This collaborative aspect was considered a significant strength of the effort.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer mentioned that the team presented a clear plan for future research, which includes several specific areas of focus:

Operando diffraction mapping studies on the Li metal anode to improve Li utilization and understand the differences between anode-free and Li-anode configurations.

Diffraction mapping studies on the Li-S cell to improve S utilization and understand phase transitions, morphology, speciation, and inhomogeneity, along with their dependence on cell conditions.

Further XRD, pair distribution function (PDF), and spectroscopy studies on the Li-metal SEI using the B500 electrolytes.

Reviewer 2:

The reviewer noted that the proposed questions for future research were relevant and specific. However, there was a mention of “N/A” in the section about “Remaining challenges and barriers,” which the reviewer found unusual, as most PIs in other projects typically list the problems to be addressed in their future research.

Reviewer 3:

The reviewer suggested that future research should connect present results to proposed solutions.

Reviewer 4:

The reviewer indicated that the researcher's plans seemed to involve further understanding the failure of Li, S, and NMC and its connection to the electrolyte. The reviewer expressed curiosity about the outcomes of this research.

Reviewer 5:

Overall, the reviewer found future plans to be acceptable and highlighted that the questions to be addressed in the next year were interesting and had the potential for significant impact within the B500 program if the work proved successful.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer found that the project aligns with the VTO objective to develop batteries with a specific energy of 500 Wh/kg and featuring Li metal anodes. They also noted that the project places a strong emphasis on developing and demonstrating effective characterization techniques, particularly through the use of synchrotron diffraction and spectroscopy methods.

Reviewer 2:

The reviewer acknowledged the significance of advanced synchrotron X-ray techniques as powerful tools for *in situ* or *operando* materials characterization across multiple length scales. They believed that the project's efforts would deepen the understanding of material properties and reaction mechanisms in Li-ion batteries, ultimately accelerating their application in EVs.

Reviewer 3:

The reviewer stated that the relevance was "okay."

Reviewer 4:

The reviewer emphasized the importance of achieving 1,000 cycles for high-energy batteries, considering it a critical barrier that must be overcome for practical use in vehicles. They appreciated the researcher's innovative techniques for studying these systems and believed that they could provide valuable insights into the performance of existing battery systems.

Reviewer 5:

Overall, the reviewer concluded that the project was highly relevant to the B500 program and aligned well with the VTO subprogram objectives for batteries. They saw the project's relevance as evident and crucial to advancing battery technology.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that based on the above evaluations, the project's resources were deemed sufficient and appropriate to achieve the stated milestones on time.

Reviewer 2:

The reviewer affirmed that the team had access to the synchrotron facilities and possessed expertise in both battery studies and synchrotron X-ray techniques.

Reviewer 3:

The reviewer stated that the resources were sufficient.

Reviewer 4:

The reviewer observed that the researcher demonstrated a strong understanding of how different techniques could contribute new insights to the problem, noting that they performed well under the current funding.

Reviewer 5:

The reviewer commented that resources appeared to be sufficient because the necessary work was being accomplished. However, the reviewer questioned why the resources allocated to this specific BNL team were not listed in the presentation materials provided. This omission made it challenging to assess how effectively funds were utilized. Nevertheless, the reviewer appreciated the fact that the work was progressing, regardless of the level of funding received. The reviewer recommended including a clear breakdown of the funding allocated to this 3-PI team at BNL in next year's presentation.

Presentation Number: BAT368
Presentation Title: Full Cell Diagnostics and Validation to Achieving High Cycle Life
Principal Investigator: Eric Dufek (Idaho National Laboratory)

Presenter

Eric Dufek, Idaho National Laboratory

Reviewer Sample Size

A total of seven reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 86% of reviewers felt that the resources were sufficient, 14% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

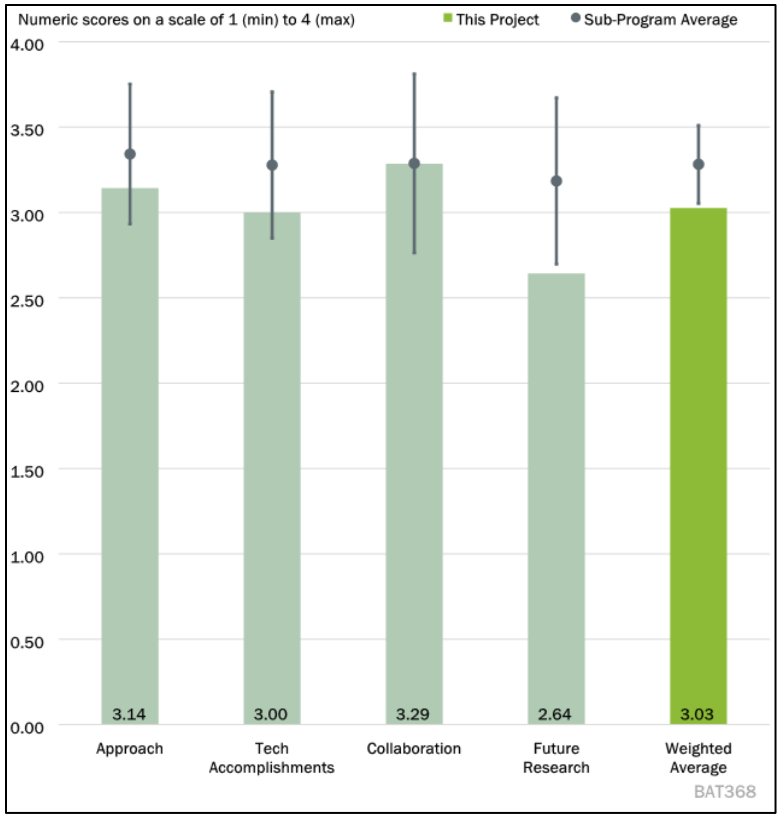

Figure 1-14 - Presentation Number: BAT368 Presentation Title: Full Cell Diagnostics and Validation to Achieving High Cycle Life Principal Investigator: Eric Dufek (Idaho National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer noted that the project's scope extends beyond "diagnostics and validation," contrary to what its title suggests. It is, in fact, a comprehensive battery research and development (R&D) endeavor, focusing on cell-level development by integrating advancements in materials and cell design. The reviewer affirmed that the project's targets, including 500 Wh/kg energy density, 5–10 Ah capacity, and 1000 deep cycle, along with well-defined milestones, were clearly articulated.

Reviewer 2:

The reviewer stated that the project is appropriately centered on high cathode loading and lean electrolyte, a strategic approach that facilitates the transfer of knowledge and findings to the industry.

Reviewer 3:

The reviewer remarked that while the project is designed to explore the lifetime aspects (cycle life and calendar life) concerning external pressure using sulfur cathode and NMC811 cathode, it has primarily concentrated on Li metal anode to enhance performance and employed advanced analysis techniques such as EOCV (electrochemical open circuit voltage), dQ/dV (change in voltage with change in capacity), and dP/dV (change in pressure with change in voltage). The reviewer expressed the view that it is challenging to conclusively assert that the work fully supports full cell diagnostics and validation, as comprehensive diagnostics should encompass not only the anode but also the cathode, electrolyte, and various internal and external variables.

Reviewer 4:

The reviewer commented that the project's strategy of using coin cells for materials optimization followed by single-layer pouch cells for realistic performance validation and failure mechanism understanding is sound. In the initial stages of materials discovery and development, single-layer pouch cells offer valuable insights without the complexities associated with multiple-layer pouch cells.

Reviewer 5:

The reviewer affirmed that the multi-faceted approach adopted by the project is suitable for a complex program in a field that has been extensively researched.

Reviewer 6:

The reviewer observed that the project appears to involve the INL in the production of Li/S, Li/SPAN, and Li/NMC811 coin cells and pouch cells, as well as the testing of certain electrolytes and the evaluation of pressure levels. However, it was noted that the project's connection to other efforts aimed at producing electrodes from the same materials and its unique contributions were not entirely clear.

Reviewer 7:

Regarding the first task related to SPAN production and slurry development, the reviewer stated that the work seemed to be progressing well and supporting the overall B500 team, including material sent to GM. However, for the second task involving aging of NMC811 cells and the impact of pressure, the reviewer commented that the work appeared to be in its preliminary stages, and the potential impact of the data on the project's objectives was not entirely clear. The reviewer noted that the tests conducted and presented so far may not be sufficient to fully understand how real cells behave under real conditions. Nevertheless, the reviewer acknowledged that it was a promising start and suggested that more information about the testing matrix and ongoing or upcoming activities would have been beneficial.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer acknowledged that the project plan was successfully executed in terms of technical achievements. Significant progress was noted in three key areas: SPAN electrode recipe development, pressure tuning on Li-NMC811, and calendar aging assessment on Li-NMC811 cells. However, the reviewer raised a valid point regarding the calendar life study, emphasizing that solely relying on normalized capacity to track aging effects might not provide a comprehensive evaluation. The reviewer suggested that other parameters, especially those critical for specific applications, should be considered when evaluating different materials and cell designs.

Reviewer 2:

The reviewer expressed appreciation for the valuable new information about coupled mechanical and electrochemical responses, commending the team's efforts in the area of calendar aging.

Reviewer 3:

Regarding technical accomplishments, the reviewer found them to be somewhat achieved. The addition of the form to assess the effect of external pressure on both the anode and cell was viewed as a notable achievement. The utilization of EOCV (electrochemical open circuit voltage) and calendar aging differential analysis to understand battery cycle and calendar life was acknowledged as a standard practice. However, the reviewer pointed out that while the project met the milestones as stated, those milestones were more like general task descriptions than specific, measurable goals. The reviewer suggested that refining the milestones with specific numerical targets would facilitate a clearer assessment of progress.

Reviewer 4:

The reviewer expressed expectations of a high level of accomplishment based on the funding level. However, within the context of the challenging battery chemistry improvements, the accomplishments were considered adequate. The reviewer raised concerns about the project's ability to achieve the stated milestones based on the progress observed to date, suggesting that some industrial efforts might be ahead in meeting state program milestones.

Reviewer 5:

The reviewer provided an overview of the team's accomplishments in each of their objectives. For the first accomplishment involving moving from coin cells to pouch cells with a Li/SPAN system, the reviewer noted good repeatability and cyclability, especially at 10 psi. For the second accomplishment related to finding ways to cycle Li/NMC811 without dendrites, the reviewer mentioned success using a constant volume system with foam support, leading to more uniform and compact Li deposition. Regarding the third accomplishment, it was established that holding a Li/NMC cell at 4V and higher pressure resulted in a longer calendar life compared to 4.4V and lower pressure.

Reviewer 6:

The reviewer reiterated a concern about how the project's results align with the work of other consortium members and emphasized the need for greater clarity in this regard.

Reviewer 7:

The reviewer observed that progress on the first objective, involving SPAN material production and calendaring techniques, appeared more advanced compared to the aging studies on Li-NMC811, which were still in the early stages of producing results. The reviewer also noted the presence of eight publications but requested clarification on which of these publications were the primary outcomes of this team's work within the larger B500 team. Highlighting the team's primary contributions in the publications would have been beneficial.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer noted that the project is a part of the B500 consortium, which involves various national laboratories, universities, and industry companies, and commended the well-defined roles of the participating teams.

Reviewer 2:

The reviewer described collaboration with GM as sufficiently deep to have a real impact. However, the reviewer pointed out the need for clarity when using terms like "mAh/g," emphasizing that specifying the unit of measurement (grams of what) is essential. Additionally, the reviewer questioned the utility of mAh/g as a measure and advised against presenting CE on a 0%–100% scale, as it does not provide useful information.

Reviewer 3:

The reviewer acknowledged that collaborative efforts within the consortium have been facilitated through electrode shipments to some partners but expressed a desire to see more bilateral collaboration between team members.

Reviewer 4:

The reviewer appreciated the diverse composition of the team, which included national laboratories, academia, and industry representatives. However, the specific contributions from each team member were not clearly delineated. The reviewer suggested that a breakdown of tasks by team members would be helpful for evaluation.

Reviewer 5:

The reviewer noted that materials were being shared among team members. The reviewer emphasized the need for improved coordination within the entire B500 consortium.

Reviewer 6:

The reviewer observed a clear handoff of work to GM and suggested that more coordination within the B500 consortium would be beneficial.

Reviewer 7:

Regarding the INL-led team's collaboration with the rest of the B500 team, the reviewer noted that efforts were well-coordinated, particularly in ensuring quality SPAN material access. However, there was concern about the schedule for aging studies, and the reviewer recommended accelerating the timeline to provide actionable information to other B500 participants in a timely manner. It was also unclear from the presentation which members of B500 were relying on the data and analysis generated by the INL-led team.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer noted that high-level future plans were provided but suggested that they could be made more specific. Given the demonstrated R&D capabilities, the team was considered highly likely to achieve the targeted objectives.

Reviewer 2:

The reviewer expressed the belief that the project should incorporate a theoretical component and mentioned that the group was planning to do so. Additionally, it was emphasized that state of health (SOH) should not be defined solely by capacity and that decreases in voltage should also be accounted for.

Reviewer 3:

The reviewer mentioned difficulty in discerning all the details of what the PI would undertake in the future. For instance, transitioning from small cells to large format cells, such as moving from coin cells to pouch cells, was suggested to require a consistent approach for advanced analysis to highlight any differences. The reviewer recommended a more detailed description of the future plan, including advancements.

Reviewer 4:

The reviewer recommended more specific future work, particularly in characterizing the calendar life of Li/SPAN SLPC to assess the extent to which the polysulfide issue is mitigated with the SPAN cathode.

Reviewer 5:

The reviewer stated that the program is on the most viable path to achieve the objectives.

Reviewer 6:

While stating that the program was on a viable path to achieve its objectives, the reviewer pointed out that much of the future work seemed focused on better understanding the results obtained thus far.

Reviewer 7:

The reviewer raised concerns about the generic and somewhat vague descriptions of future work. Specific examples were provided, such as the need for prioritization in understanding cell performance with varied use protocols and clarification regarding "Continued integration of Keystone 1 and 2 advancements," as Keystone 1 and 2 were not explained in the presentation. Further context would be beneficial for better comprehension.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer commented that cell-level battery design and fabrication represent the final steps in delivering high-energy, low-cost batteries for vehicle electrification.

Reviewer 2:

The reviewer stated that this was highly relevant.

Reviewer 3:

The reviewer affirmed that the project aligns with the VTO goals and objectives. However, the reviewer noted the absence of many technical details and emphasized the importance of understanding the failure mechanisms of high-energy cells with lithium metal anodes. The reviewer requested more fundamental approaches to elucidate the full cell failure mechanisms, including validation for not only Li metal but also cathode/electrolyte interfaces.

Reviewer 4:

The reviewer acknowledged that achieving 1000 cycles in a 500 Wh/kg cell was highly relevant to VTO objectives but expressed doubts about the feasibility of reaching these targets with a sulfur-based cathode (Li/S system). The reviewer recommended benchmarking Li/S against LFP (lithium iron phosphate) instead of high-energy density NMC cathodes, emphasizing the importance of the abundance of sulfur in the supply chain. The reviewer proposed setting a goal of 1000 cycles in a 300 Wh/kg Li/S cell and incorporating Li/S into the EaCAM rather than B500.

Reviewer 5:

The reviewer found the project relevant to VTO objectives, particularly in achieving high-energy dense batteries with relatively abundant materials.

Reviewer 6:

The reviewer emphasized that the work was focused on advanced batteries with Li-ions and Li metal, aiming to achieve higher energy density with longer life, which was in line with VTO objectives.

Reviewer 7:

The reviewer considered the work highly relevant, provided it was conducted at a comprehensive level. The reviewer noted the importance of gathering extensive data about real systems, as failure in a real system with high loadings and lean electrolyte can differ significantly from laboratory-scale demonstrations.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer noted that the resources were efficient for achieving the milestones, with close collaboration with other teams in the B500 consortium.

Reviewer 2:

The reviewer found the resources to be sufficient.

Reviewer 3:

The reviewer expressed reservations about recommending the proposal for renewal based on the following points:

The reviewer believed that the project's purpose was somewhat misleading, as most of the work focused on external pressure applied to Li metal and its diagnosis in full cells, which represented only one aspect of the interaction and understanding of interfacial reactions from the Li metal side.

The reviewer raised concerns about the collaboration with partners, describing it as unilateral or not fully described in the proposal. The reviewer also suggested that the potential impact of the work for the scientific community was limited in this case.

Reviewer 4:

The reviewer reiterated that resources were sufficient for the stated milestones.

Reviewer 5:

The reviewer noted that it was a large program, but it involved relatively mature technology development, which might require higher funding levels.

Reviewer 6:

The reviewer observed that the future research appeared to align with what had already been completed, assuming that the resources for this work were adequate.

Reviewer 7:

The reviewer noted that it was not entirely clear how much funding within B500 was available for this specific project. While funding numbers were provided for B500 as a whole, the reviewer noted that the project appeared to be fairly appropriately resourced, considering the number of people involved and the results achieved thus far.

Presentation Number: BAT377
Presentation Title: ReCell–Overview and Update
Principal Investigator: Jeffrey Spangenberger (Argonne National Laboratory)

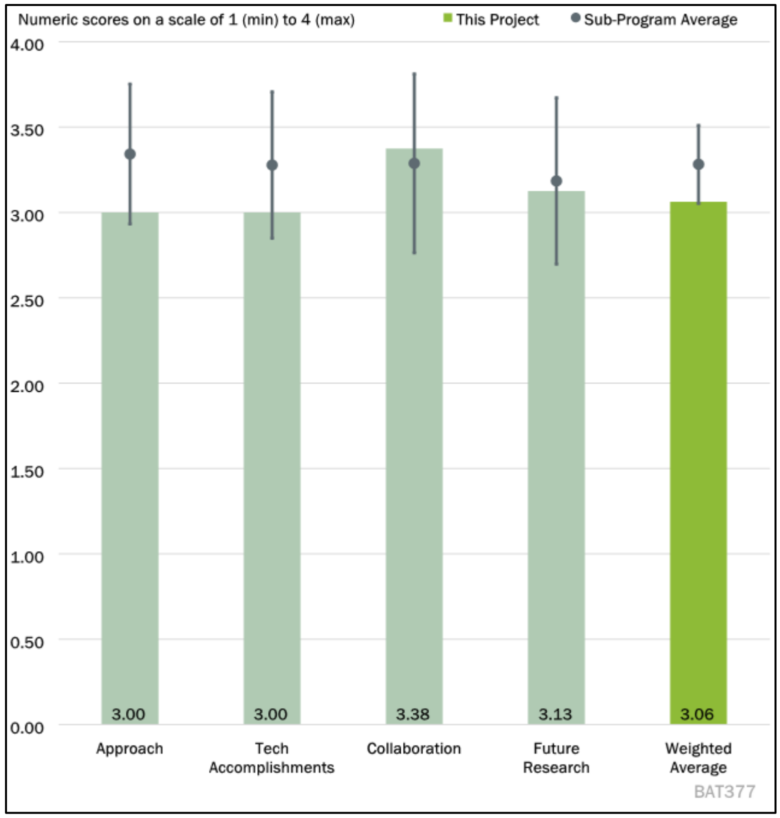

Figure 1-15 - Presentation Number: BAT377 Presentation Title: ReCell–Overview and Update Principal Investigator: Jeffrey Spangenberger (Argonne National Laboratory)

Presenter

Jeffrey Spangenberger, Argonne National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 25% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

During the session, there was a notable emphasis on the goal of making recycling economically viable for the industry, which was deemed a significant objective. However, the reviewer raised several points of concern and suggested the need for a broader approach:

The reviewer pointed out that while there were innovative ideas and plans to try out these ideas at a larger scale for NMC cathodes, there appeared to be limited activity addressing the cost challenges of other materials like LFP. The reviewer highlighted the importance of addressing cost challenges for less economically viable materials, as these would be present in many cells in the future. Making cost-loss materials attractive through recycling innovations could have a more substantial long-term impact.

The reviewer mentioned that the project was planning to build a pilot plant but noted that the outcomes and objectives of this approach were not clearly defined. Questions were raised about whether the pilot plant aimed to prove new technologies developed by ReCell, improve process economics and scale-up models, or enable cell manufacturers to become accustomed to using recycled materials.

Reviewer 2:

The reviewer noted that while the presentation provided a high-level overview and update, it lacked detailed information on the projects within ReCell.

Reviewer 3:

The reviewer appreciated the broad and comprehensive scope of ReCell and stated that the research conducted had meaningfully addressed this scope. The approach of dividing the work into focus areas and ending projects prematurely if they showed minimal promise for commercialization was considered appropriate. However, the reviewer expressed a desire to know if there had been any areas of study terminated due to lack of promise. The reviewer recommended greater outreach to the industry and continuous benchmarking to avoid duplicating efforts that industry may have already solved. Additionally, the reviewer emphasized the importance of ensuring that the parameters of the cooperative research and development agreement (CRADA) model were not prohibitive and did not discourage the adoption of technologies developed by ReCell by recyclers.

Reviewer 4:

The reviewer acknowledged that technical barriers, particularly lowering the cost of recycling as a percentage of the battery cost and decreasing the environmental footprint compared to using natural resources, were discussed in the overview. The approach to address these barriers through direct recycling methods and the use of the EverBatt model to evaluate costs of proposed technologies was considered well-designed. The addition of investigations into second-use and hydro/pyro processing was noted, though the reviewer expressed some reservations about the potential expense of the pyro process and recommended further justification for its research. Overall, the timeline for the project was deemed reasonable.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer acknowledged the major accomplishment of proving the concept for direct recycling but raised some concerns about the overall progress of the project, particularly in relation to the entire battery system and materials beyond the cathode. Despite the involvement of over 80 people and the project's duration of over four years, the reviewer noted that the output of 20 inventions and 40 publications seemed relatively low.

Reviewer 2:

The reviewer mentioned that while progress had been made according to the project plan, more work was needed to demonstrate that direct recycling could work on a larger scale, both technologically and economically.

Reviewer 3:

The reviewer provided comments specific to different technology areas within the project:

Direct Recycling: The reviewer questioned the continued focus on upcycling and cathode separation, suggesting that these approaches might primarily be aimed at end-of-life (EOL) batteries. The reviewer emphasized that the most promising opportunity for direct recycling could be plant scrap if economically justified. While acknowledging that these techniques could be demonstrated at the laboratory scale, the reviewer pointed out that practical implementation could be challenging due to non-idealities and competition with more robust and scaled approaches. The reviewer also found the work on the conversion of polycrystalline to single crystal interesting.

Advanced Resource Recovery: The reviewer noted valuable expansion of ReCell's scope and promising results in multiple areas. The processing of sodium sulfate was recommended as an additional area of focus, despite existing solutions not being economically attractive.

Design for Sustainability: The reviewer expressed doubts about the novelty of some projects in this area and suggested continuous monitoring of companies that are commercializing the explored study areas.

Modeling and Analysis: The reviewer praised the excellent results in this area and highlighted the potential value of the multiple models being developed for supply chain and technology optimization and analysis.

Reviewer 4:

The reviewer noted that the presentation provided an overview of ReCell Center research activities and that most technical accomplishments occurred under other companion projects. The focus of this project was primarily on coordinating with other ReCell partner members, engaging with industry, and expanding facilities, aligning well with the project plan.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer emphasized the importance of clarifying that multiple national laboratories are collaborating within the ReCell Center and coordinating their efforts to address project challenges.

Reviewer 2:

The reviewer stated that the level of collaboration with industry, research institutions, and universities was praised as impressive.

Reviewer 3:

The reviewer pointed out that in certain project areas, such as Design for Sustainability, there should be more discussion and interaction with industry stakeholders. While participation across universities and national laboratories was considered adequate, the reviewer stressed the importance of enhanced collaboration with industry to ensure that successful research findings find interested customers for adoption and scaling. Such collaboration could also help identify practical problems and challenges that may be related to the technology and must be considered.

Reviewer 4:

The reviewer provided information about the ReCell consortium, which consists of four national laboratories and four universities, each with specific roles. The addition of INL to the consortium was commended, and it was noted that the consortium had organized Industry Collaboration Meetings, bringing several industrial partners together to collaborate on various aspects of recycling.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer acknowledged that progress in recycling had been made through ReCell and across the United States in various aspects of recycling. The current structure with a more specific sub-thrust focus on work was deemed agreeable. However, the reviewer suggested several points for consideration going forward:

Reporting progress toward a recycle cell cost goal and updating the percentage of a cell that can be made using recycled parts in a single cell could be helpful metrics for tracking and demonstrating progress.

Clearer outcomes and benefits of scale-up should be defined and justified in future work.

For the lower-value parts of batteries, the reviewer recommended emphasizing additional work on second-life or non-battery product uses.

Given the potential hazards associated with dealing with used batteries, the reviewer proposed that the innovative minds at national laboratories could focus on safety methods or products to protect workers, which could be considered by the recycling center.

Reviewer 2:

Regarding the presentation of future work areas, the reviewer expressed the need for more detail to fully understand if the proposed future work would achieve its targets.

Reviewer 3:

The reviewer found the proposed future work points to be relevant and well-defined. However, the reviewer suggested prioritizing certain items, such as increasing industry involvement and feedback and facilitating technology transfer to recyclers. The reviewer also pointed out important focus areas not explicitly listed, including what to do with lower-value byproducts from recycling (excluding Li, Ni, Co), such as sodium sulfate, plastics, and graphite. Additionally, the reviewer found the work on graphite to graphene interesting. Another emerging focus area highlighted by the reviewer was LFP recycling.

Reviewer 4:

Overall, the reviewer found the proposed future research plan was consistent with the overall objective of the ReCell consortium, and achieving these objectives would continue to make progress toward the eventual goal.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer emphasized the critical nature of recycling work and deemed the ReCell Center relevant in this context.

Reviewer 2:

The reviewer noted that the project and activities conducted at ReCell supported the objectives of the VTO related to reducing the cost of EV battery packs.

Reviewer 3:

The reviewer found the comprehensive approach to a wide range of process options in battery recycling and EOL redeployment highly relevant. Identifying sustainable recycling approaches and separation techniques was considered critical, particularly in maximizing the benefits as society transitions to e-mobility.

Reviewer 4:

The reviewer concluded that the project was very relevant to addressing several concerns related to the broader adoption of battery EVs, aligning with VTO’s subprogram objectives. These concerns included addressing EOL battery issues, recycling to recover valuable materials for future batteries, and addressing supply chain concerns.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer noted that for the number of people involved and the project goals, the resources were currently deemed sufficient. However, the reviewer cautioned that resource use could become excessive if the project team failed to define and then achieve the outcomes sought by building a pilot plant.

Reviewer 2:

The reviewer stated that there appeared to be sufficient support from stakeholders.

Reviewer 3:

The reviewer commented that the resources seemed sufficient and, in some cases, possibly more than sufficient, particularly for topic areas with limited promise for wide deployment by industry.

Reviewer 4:

Regarding funding, the reviewer provided that in the first two years, the funding was $14.68 million, and for FY 2022 and FY 2023, it was $18.9 million. The reviewer noted that the amount of funding appeared to be more than sufficient but pointed out that it was not clear how much of the funding went to the operation, project management, and collaborations within ReCell.

Presentation Number: BAT386
Presentation Title: eXtreme Fast Charge Cell Evaluation of Lithium-Ion Batteries (XCEL)–Overview and Progress Update
Principal Investigator: Venkat Srinivasan (Argonne National Laboratory)

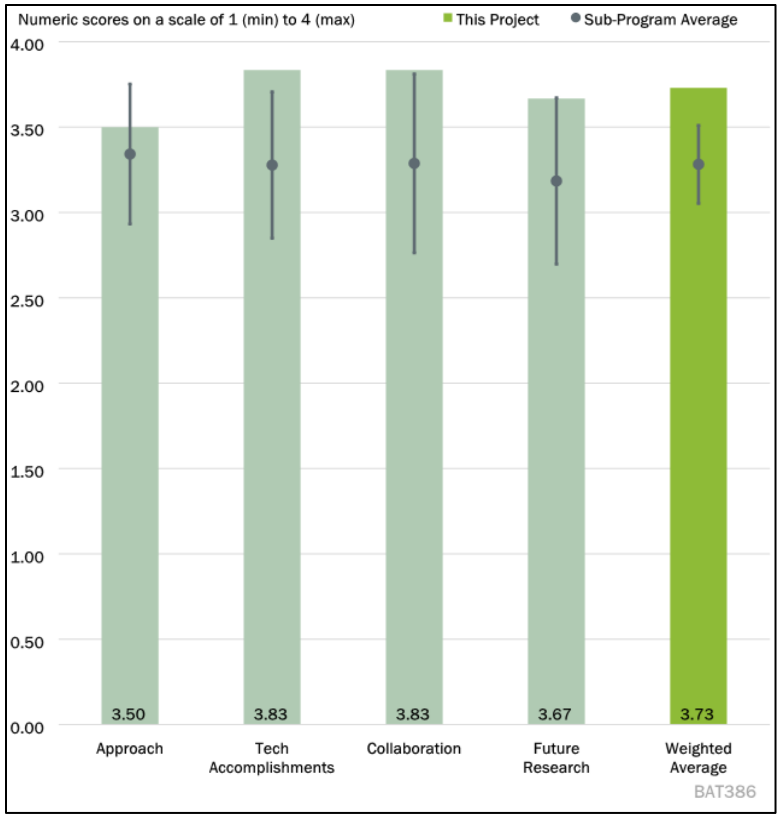

Figure 1-16 - Presentation Number: BAT386 Presentation Title: eXtreme Fast Charge Cell Evaluation of Lithium-Ion Batteries (XCEL)–Overview and Progress Update Principal Investigator: Venkat Srinivasan (Argonne National Laboratory)

Presenter

Venkat Srinivasan, Argonne National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer commended the program for effectively addressing technical barriers related to extreme fast charging (XFC), including cell degradation under fast charging conditions, and reducing high cell costs to increase recharge acceptance.

Reviewer 2:

The reviewer noted that the team had done excellent work by pursuing various directions to design a unified approach to eXtreme Fast Charge Cell Evaluation of Lithium-Ion Batteries (XCEL). They emphasized that the parallel development of advanced anode, cathode, and electrolyte components was critical in addressing degradation mechanisms in fast charging. The reviewer also emphasized the importance of considering long-term cycling and calendar life impacts. The proposed ML approach was regarded as an excellent next step in the program.

Reviewer 3:

The reviewer highlighted that the project correctly identified the three critical barriers (Li plating, temperature rise, cathode particle cracking) preventing LIB chemistry from being charged at a fast rate. The project adopted separate approaches to address these challenges, and through inter-lab collaboration, some progress had been made. This progress allowed LIBs of graphite/NMC811 to be charged at a 6C rate with minimal fading and Li plating.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer noted that progress had been made, and major go/no-go milestones had been met in the project.

Reviewer 2:

The reviewer stated that the team had achieved all the targets they had set for the project. They mentioned that there were some advances in certain topics and roadblocks had been identified.

Reviewer 3:

The reviewer highlighted that the researchers had adopted new electrolyte compositions, redesigned anode architecture, and integrated CNTs to facilitate fast ion transport and charge transfer. These novel techniques had contributed to the project's achievements in fast charging capability.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer stated that the collaborations among team members are excellent.

Reviewer 2:

The reviewer said that the collaboration and coordination across the project teams are outstanding.

Reviewer 3:

The reviewer commented that the researcher in the national laboratories have shown highly collaborative working manner in pursuing the resolution of technical barriers.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer found the proposed future work to be properly illustrated, suggesting that it aligns with the overall scope of the project. However, they expressed a desire to see a technology transition plan illustrated and raised uncertainty about the involvement of battery OEMs in the program. Additionally, the reviewer recommended considering the impact on battery shelf life, even though some new designs appear to facilitate XFC, and some understanding of XFC mechanisms has been achieved in the program.

Reviewer 2:

The reviewer emphasized the critical nature of identifying degradation mechanisms as various enablers are studied, seeing this as essential for the project's success.

Reviewer 3:

The reviewer suggested that future efforts should focus more on electrolyte improvement. They pointed out that knowledge gained from low-temperature electrolyte projects funded by DOE and the new electrolyte classes invented by PNNL could provide an excellent starting point for enhancing fast-charging capabilities.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer consistently emphasized the high relevance and importance of the project in the context of electrification and the adoption of EVs on a large scale.

Reviewer 2:

The reviewer noted that XFC remains a critical issue for the widespread adoption of EVs and that this program provides strong support to the objectives of the VTO.

Reviewer 3:

The reviewer found the project to be extremely highly relevant, underscoring its significance in addressing the challenges and advancements needed for the adoption of electrification and EVs.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said that the resources assigned to this program are appropriate.

Reviewer 2:

The reviewer commented that the funding planned for this project is sufficient to achieve the proposed goals.

Reviewer 3:

The reviewer stated that the resources provided are sufficient.

Presentation Number: BAT423
Presentation Title: Development of New Electrolytes for Lithium-Sulfur Batteries
Principal Investigator: Gao Liu (Lawrence Berkeley National Laboratory)

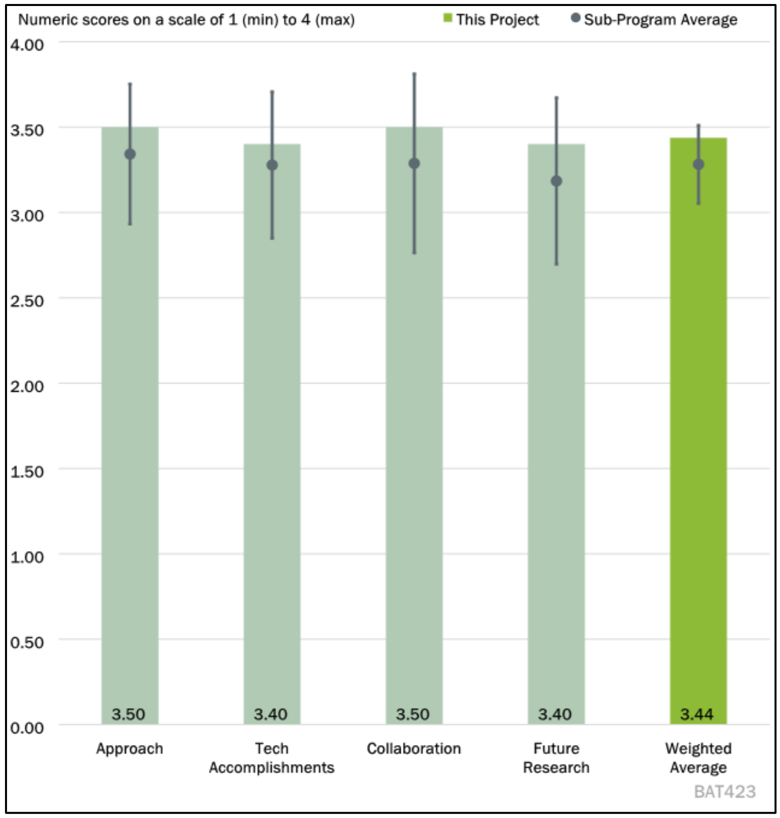

Figure 1-17 - Presentation Number: BAT423 Presentation Title: Development of New Electrolytes for Lithium-Sulfur Batteries Principal Investigator: Gao Liu (Lawrence Berkeley National Laboratory)

Presenter

Gao Liu, Lawrence Berkeley National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer said that new concepts were introduced for electrolytes of Li-S batteries, effectively addressing most associated issues. They also remarked on the synthesis, characterization, and testing of the new electrolytes in electrochemical cells and the investigation into mechanisms of polysulfide retention.

Reviewer 2:

The reviewer commented on the successful mitigation of technical barriers related to polysulfide reactions with Li-containing anodes using the new electrolyte. They acknowledged the project’s proper design and the group’s reasonable approach, combining amphiphilic molecules with Li salt and cosolvent. Additionally, they noted the identification of potential issues and proposed strategies to address them.

Reviewer 3:

The reviewer expressed that the technical barriers were effectively addressed, particularly in terms of cycle life performance. They praised the well-designed project with a reasonable timeline schedule. Specific achievements were articulated, such as the identification of T5FDLiTF electrolyte and impressive performance metrics, including high capacity and cycle efficiency.

Reviewer 4:

Regarding the project's overarching goal, the reviewer affirmed that it aims to improve the energy density and cycling/calendaring life of Li-S batteries. They observed the project's focus on promoting polysulfide affiliation with the electrode substrate to prevent the shuttle effect and enable stable Li metal deposition or high-capacity alloy anodes. Moreover, they verified the utilization of advanced characterization facilities and found the approach promising and the timeline reasonable.

Reviewer 5:

The reviewer commended the investigators for their work on novel electrolytes and additives aimed at addressing barriers in Li-S batteries. However, they questioned the project's failure to meet the objective of developing high-ion conductivity electrolytes. The reviewer noted that the reported conductivity values fell short of industry standards. Additionally, they clarified the absence of commentary on this matter and the neglect of electrolyte viscosity. Concerns were raised about the potential impact of micelles on viscosity as they become more concentrated.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer noted that electrolytes have been proposed, synthesized, and tested. They found the results promising, although there is still some clear cell degradation effect that needs to be addressed.

Reviewer 2:

The reviewer commented that the team has demonstrated systematic studies towards their final target and distributed their workload evenly within a suitable timeline. They acknowledged that the team accomplished their work on time and made good progress. The new electrolyte shows promising performance and a strategy to address soluble polysulfide reaction with the Li anode. However, the reviewer suggested that it would be beneficial to account for potential issues that may arise in future studies.

Reviewer 3:

In terms of technical progress, the reviewer mentioned that the team has made significant advancements. For instance, they identified an optimized T5FDLiTF electrolyte with superior cell performance for Li-S batteries using amphiphilic fluorinated additives. The inclusion of full cell tests with pre-lithiated alloy anodes was recognized as a significant step towards practical high-energy, low-cost batteries. However, the reviewer pointed out that no data were provided for the characterization of solvation and polysulfides dissolution.

Reviewer 4:

The reviewer highlighted the team's achievements over the past year, noting that they have met milestones effectively. Specifically, the team optimized the structure of electrolytes with amphiphilic fluorinated additives, hydrofluoroether solvents, dioxane solvent, and Li salts. The reviewer also commended the identification of the T5FDLiTF electrolyte combination as a superior composition for Li-S battery applications. Additionally, the team's implementation of diffraction characterization techniques to understand the micelle solvation mechanism of the electrolytes and their use of a protected pre-lithiated alloy anode for sulfur cathode-based batteries were recognized as important contributions.

Reviewer 5:

The reviewer pointed out that the electrochemical results were not documented in the review regarding cathode loadings and the ratio of electrolyte to active cathode material. They stressed that this information is crucial for comparison with other research since specific capacities and cell cycle life are highly sensitive to these variables. The reviewer suggested that the investigators include this type of information or at least provide a basis for comparison in their reports, given the extensive research conducted on these systems in recent years. Furthermore, they recommended testing the cells to higher cycle life, such as 100 cycles compared to the reported 20 cycles, as the Li-S system is known to suffer sudden declines in performance as the anode degrades.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer suggested that while numerous collaborations are mentioned, it would be beneficial to demonstrate more about the integration of this project with its long list of collaborators in the future.

Reviewer 2:

The reviewer noted that the collaboration within the project team seems strong, with a well-defined list of collaborators, and potentially, there may not be a need for more collaboration. Roles and responsibilities for the various collaborations are clearly defined, and cross-functional cooperation and communication among team members appear cohesive, indicating a commitment to accomplishing the project.

Reviewer 3:

The reviewer found the collaboration within the project team to be excellent. They highlighted successful X-ray characterization of electrolyte micelle structures, polysulfide dissolution, and precipitation in collaboration with synchrotron physicists. The micro- and nanostructures of the amphiphilic electrolytes were characterized in collaboration with ORNL and Texas A&M University. Additional collaborations were mentioned, including General Motors for verifying the Li-S performance, Conamix Inc for testing the amphiphilic electrolytes, and BAE for technology inputs and commercial aspects of this technology for potential defense applications.

Reviewer 4:

The reviewer recognized that the team has involved multiple researchers from two national laboratories, two universities, and three industries in this project. They also noted that the PI has collaborated effectively with these partners on material synthesis, characterization, and cell testing.

Reviewer 5:

The reviewer pointed out that a large group of collaborators has been assembled, which should serve the project's goals well and could potentially provide answers to questions raised by the reviewer, such as testing to higher cycle life and measuring additional electrolyte properties.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer noted that the project has clear future goals, and based on the current report, they are likely to be successfully accomplished.

Reviewer 2:

The reviewer observed that the future work aligns with the project plans and will help provide an in-depth understanding for further development.

Reviewer 3:

The reviewer pointed out that the project has clearly defined a purpose for future work with a clear milestone planned for FY 2023. They mentioned that, based on the PI's collaborations and detailed schedules, the plans could be executed on time.

Reviewer 4:

The reviewer stated the proposed future work will be primarily focused on the optimization of electrolytes to improve their properties, such as ion transport, to enhance performance. Additionally, the team plans to work on cathode electrode design, specifically targeting high sulfur (S) loading and lean electrolyte conditions for Li-S batteries.

Reviewer 5:

The reviewer stated the future work intends to address some of the previous issues. The reviewer suggested paying attention to cathode loading and the electrolyte-to-cathode ratio to meet current standards in the field.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer affirmed that the project is well aligned with VTO objectives.

Reviewer 2:

The reviewer noted that the project demonstrates strong relevance to VTO's goals, particularly in the context of low-cost, high-energy-density batteries for electrification and support of the stated objectives.

Reviewer 3:

The reviewer emphasized that this project supports the overall VTO subprogram objectives for low-cost and high-energy Li-S batteries, which have potential applications in electrical energy storage.

Reviewer 4:

The reviewer articulated that the success of the project can address the challenges associated with the high cost and low energy density of Li-ion rechargeable batteries. They highlighted the potential of emerging Li-S batteries to be both high energy-density and low cost, enabling the utilization of low-cost and abundant sulfur as a major chemical component for electrical energy storage.

Reviewer 5:

The reviewer underscored the high relevance of this work in supporting the VTO subprogram objectives for developing low-cost, high-energy batteries for electric transportation.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer affirmed that the resources are sufficient to carry out the proposed plans.

Reviewer 2:

The reviewer mentioned that the project's resources include a dedicated workforce with the necessary expertise to execute the project. The reviewer expressed confidence that these sufficient resources should enable the project to accomplish its goals and address potential technical challenges in future studies.

Reviewer 3:

The reviewer acknowledged the resourceful collaborations that the PI listed and stated that these collaborations should be sufficient for the project to achieve its stated milestones in a timely fashion.

Reviewer 4:

The reviewer noted that the project has involved a team with complementary expertise from national laboratories, universities, industry, and original equipment manufacturers (OEMs) to develop high-energy and low-cost Li-S batteries. The reviewer concluded that the project has sufficient resources to accomplish the proposed work.

Reviewer 5:

The reviewer deemed the collaboration provides excellent resources to carry out the work.

Presentation Number: BAT427
Presentation Title: *In Situ* and *Operando* Thermal Diagnostics of Buried Interfaces in Beyond Lithium-Ion Cells
Principal Investigator: Sumajeet Kaur (Lawrence Berkeley National Laboratory)

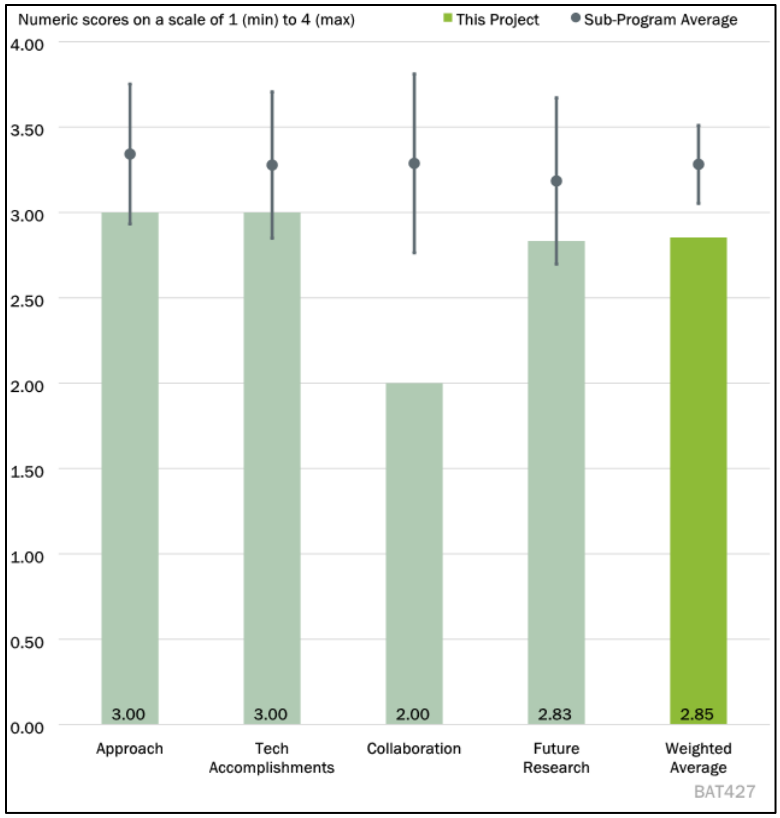

Figure 1-18 - Presentation Number: BAT427 Presentation Title: *In Situ* and *Operando* Thermal Diagnostics of Buried Interfaces in Beyond Lithium-Ion Cells Principal Investigator: Sumajeet Kaur (Lawrence Berkeley National Laboratory)

Presenter

Sumajeet Kaur, Lawrence Berkeley National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer praised the research for establishing a novel diagnostic technique that can *in situ* and *ex situ* characterize the buried interfaces in SSBs. They noted its effectiveness in distinguishing different phenomena, including entropic, kinetic, and transport properties, based on harmonics and frequency. Importantly, the reviewer highlighted that it is a non-invasive measurement method with the potential to provide valuable information, especially when combined with the new electrochemical method multiharmonic electrothermal spectroscopy (METS). They also mentioned that the project is currently in progress, displaying promising results, and aligning well with its milestones.

Reviewer 2:

The reviewer commended the project for successfully identifying potential issues related to interfacial problems in the Li-metal anode for SSB systems. They acknowledged that the project has proposed specific strategies using the thermal wave sensing technique to characterize and address these issues.

Reviewer 3:

The reviewer noted that the timeline for 2022 has been completed and highlighted the capability of METS to measure resistances at the interface of the solid electrolyte, Li-metal, and solid electrolyte.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer noted that the presented poster showcased the accomplishment of the technical part as planned and in good progress. However, they suggested that the PI should present the results following the setup milestones to make it easier for the audience to follow.

Reviewer 2:

The reviewer commented that the team presented the setup and testing results for characterizing the interface and obtained useful information for understanding the Li metal anode. They found the project plan to be reasonably planned, with milestones aligned with the project's objectives. However, they suggested that it would be beneficial to include some discussion of combining other conventional characterization techniques to comprehensively present the identified interface properties.

Reviewer 3:

The reviewer stated that the project plan was accomplished according to schedule. They recommended that impedance measurement using METS should be compared with other methods that measure resistance and resistivity for a more comprehensive assessment.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer noted that there might have been some collaboration related to the *ex situ* morphology and structure of the interfaces, and they suggested that the PI should clarify or emphasize this aspect.

Reviewer 2:

The reviewer pointed out that the collaboration was not listed. They emphasized that collaboration using other characterization techniques could be helpful in enhancing the understanding of interfacial properties as illustrated by the thermal wave sensing techniques.

Reviewer 3:

The reviewer highlighted the absence of pronouncements regarding contributions made by universities, national laboratories, and industry. They suggested expanding the testing of more cathode samples, particularly transforming them from polycrystalline to monocrystalline, especially in cases where cathodes do not contain Ni, Mn, and Co. The reviewer recommended broadening the materials for the cathodes being tested by seeking input and ideas from industry partners.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer acknowledged that the proposed future research is well-defined, targeting the remaining challenges and ongoing experiments. They also noted that the PI needs to validate the METS technique for different materials and verify its applicability on the model electrochemical system.

Reviewer 2:

The reviewer mentioned that the future work aligns with the project plans, but they suggested that it would be beneficial to have more detailed characterization results or information on material structural properties to verify the obtained results.

Reviewer 3:

The reviewer expressed a need for more information on the purpose of the future work. While they acknowledged that the project had achieved its proposed objectives, they also stated that it is very likely that the objectives will be achieved based on the proposed work.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer affirmed that the research aligns with the overall VTO batteries subprogram objectives, particularly within the SSBs program. They noted that the developed techniques have the potential to be supportive for other battery systems, aiding in understanding different phenomena on the interfaces.

Reviewer 2:

The reviewer also emphasized that the project demonstrates relevance to VTO's goals and supports its objectives.

Reviewer 3:

The reviewer pointed out that the project supports the analysis of batteries, energy-efficient mobility systems, and materials. They highlighted the significance of characterizing the solid electrolyte interface without a need to insert external agents or devices into the sample, allowing for specific morphological characterization.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer mentioned that resources are adequate to achieve the milestone in a timely fashion. However, they suggested that if more work is proposed related to the deeper analysis of the data and so on, the budget could be reconsidered.

Reviewer 2:

The reviewer noted that the project's resources include a dedicated workforce with the necessary expertise to execute the project. They expressed confidence that these resources should enable the project to accomplish its goals and tackle potential technical challenges. The reviewer also highlighted that additional resources from collaboration could enhance the understanding of the proposed work.

Reviewer 3:

The reviewer affirmed that the resources are sufficient, and they noted that the implementation of METS was achieved successfully.

Presentation Number: BAT429
Presentation Title: Electrolytes and Interfaces for Stable High Energy Sodium-Ion Batteries
Principal Investigator: Jason Zhang (Pacific Northwest National Laboratory)

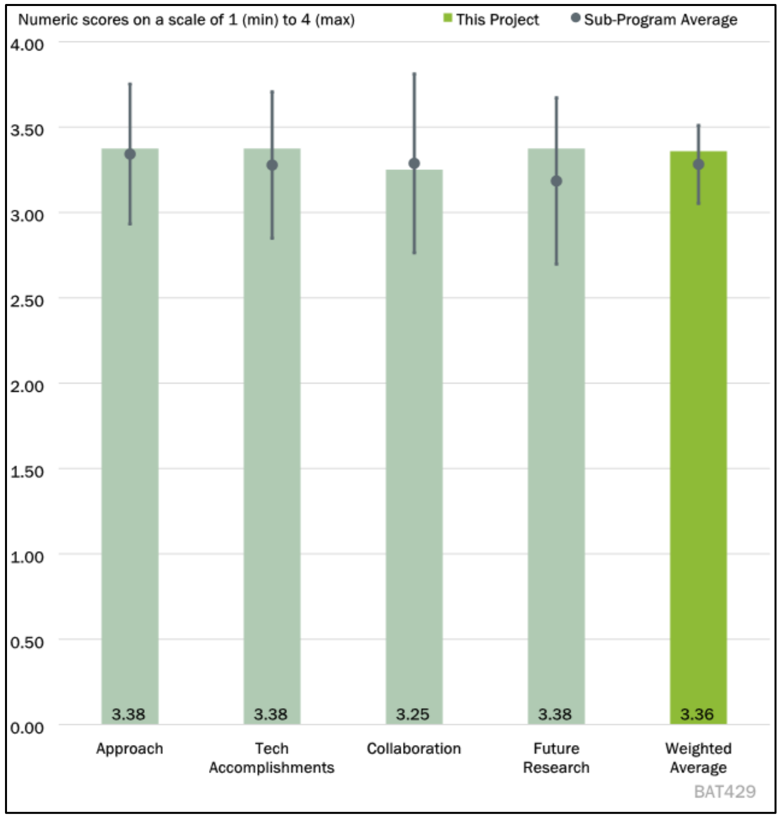

Figure 1-19 - Presentation Number: BAT429 Presentation Title: Electrolytes and Interfaces for Stable High Energy Sodium-Ion Batteries Principal Investigator: Jason Zhang (Pacific Northwest National Laboratory)

Presenter

Jason Zhang, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 25% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer remarked that the project is well designed. They noted that the development involves Prussian blue electrodes and fluorine-containing electrolytes, with the electrodes displaying a decent response in the fluorinated solvent. However, the reviewer expressed concern about initial instabilities in CE and requested the authors to comment on the reasons behind these instabilities. The reviewer sought an explanation for the incompatibility of the system with other carbonate and tetraethylene glycol dimethyl ether (TEGDME)-based electrolytes. The reviewer questioned the authors' goals regarding cycle life enhancement. They pointed out that the authors mentioned short cycle life as a barrier but requested clarification on both short-term and long-term objectives in addressing this issue. Regarding the SEM images of the electrodes, the reviewer inquired about the pressure applied during pressing to reduce porosity. They asked for clarification on the pressure levels used. Additionally, they raised a concern about how the electrodes are protected from contact with air and moisture, given the presence of water of crystallization. In terms of testing the non-flammable characteristic of the electrolyte, the reviewer sought clarification on the methodology. They asked whether the electrolyte is soaked in the membrane and inquired about the quantity of electrolyte used for this test.

Reviewer 2:

The reviewer praised the project for effectively addressing technical barriers through a well-designed approach. They commended the comprehensive strategy and logical task sequence, highlighting a robust and well-thought-out project plan.

Reviewer 3:

Recognizing that the technology is in its infancy, the reviewer affirmed that the project is addressing key technical barriers, especially cycle life, by developing novel electrolytes. They noted the application of successful design principles from other battery systems to this investigation.

Reviewer 4:

The reviewer acknowledged the project has a clear approach to investigating and optimizing stable 4V electrolytes compatible with the cathode for high-energy Na-Ion batteries. They found the timeline and work plan reasonable and suggested including details on cycling conditions to better understand material performance.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer stated that the technical progress made by the team is excellent. They highlighted the development of the fluorinated solvent for the NaFSI electrolyte. However, they requested more details on the amount of electrolyte used in the tests and the concentration of the salt in the fluorine-containing solvent. They also noted the low conductivity of approximately 0.05 mS/cm and inquired about its impact on the rate capability of the system and whether there are plans to study this further.

Reviewer 2:

The reviewer noted the Prussian blue electrode developed by the team showed a decent response. The reviewer raised questions about the long-term stability of this system and its structural stability as sodium is removed. They also mentioned a voltage plateau at 3V–3.2V and inquired about the possibility of crystallographic changes. Furthermore, they sought clarification regarding the self-extinguishing time for the non-fluorinated solvent, particularly whether it is zero and what that signifies. They asked about the material shown in the figure that appears to support a flame.

Reviewer 3:

The reviewer praised the project’s aim to design a non-flammable fluorinated solvent-based electrolyte compatible with high-energy-density Prussian blue and $NaFe_xMn_{1-x}O_2$ (NFM) cathode materials. They commended the excellent progress made by the project team in addressing this goal. The reviewer noted the thorough characterization efforts and the exploration of a new ether-based electrolyte, which they found to be commendable advancements in achieving stable sodium stripping/plating processes.

Reviewer 4:

The reviewer mentioned good progress in characterizing the commercial cathode material and producing electrodes of various densities for electrolyte analysis. They acknowledged the identification of a new electrolyte containing NaFSI, which displayed good cycling and oxidation stability. However, they expressed minor concerns about its low ionic conductivity (IC).

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer stated that the team has established collaboration with ANL and Lawrence Berkeley National Laboratory (LBNL). They noted that the team plans to provide electrode materials to ANL and LBNL for interface and materials characterization but mentioned that it is not very clear what each of the collaborators is doing. The reviewer suggested providing more details in this regard.

Reviewer 2:

The reviewer commented that the collaboration efforts with ANL and LBNL appear to be reasonable.

Reviewer 3:

The reviewer remarked that the efforts with ANL and LBNL seem to be well-coordinated and effective.

Reviewer 4:

The reviewer praised the collaborations on this project, highlighting that they span three national laboratories, each contributing their individual expertise to the project.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer acknowledged the team’s plans to optimize the electrolyte and additives to tailor the solvation characteristics, demonstrate performance in a pouch cell, and investigate the feasibility of anode-free sodium batteries using the designed electrolytes and additives. They stated that the data so far is very good and expressed confidence that the team is likely to achieve their goals in future work.

Reviewer 2:

The reviewer commented that the future research direction demonstrates an innovative approach to enhancing the long-cycling performance of Na-ion batteries. They found the focus on optimizing electrolyte co-solvents and additives to tailor solvation structures promising for achieving significant improvements.

Reviewer 3:

The reviewer noted that the proposed future work was briefly described and appeared to be appropriate.

Reviewer 4:

The reviewer found the proposed future work to be appropriate and providing logical next steps. They emphasized the importance of full cell studies involving the best cathode, anode, and electrolyte developed from this work. They suggested that such studies would provide a clear picture of the capabilities of a Na-ion system and reveal any gaps that may be missing from just half-cell studies.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer mentioned that the goals of the project are to study and develop high-energy density sodium-ion batteries while maintaining cost-effectiveness. They requested more details on the cost-effectiveness of the system using Prussian blue and how it generates high-energy density. Additionally, they noted that the project mentions the NFM system but lacks specifics regarding the targeted energy density and the strategies to achieve it. They suggested providing more details in these areas. However, the reviewer acknowledged that the project aligns with the goals of the VTO program.

Reviewer 2:

The reviewer commented that the project aligns perfectly with the mission of the VTO Battery program. They highlighted the potential of Na-ion batteries to address supply constraints associated with LIBs, making them highly relevant and significant for the program's objectives.

Reviewer 3:

The reviewer noted that this is a highly relevant area of research and supports the VTO program. They emphasized the abundance and even distribution of sodium resources worldwide, which could ultimately lower battery costs.

Reviewer 4:

The reviewer affirmed that the project supports the overall VTO Batteries program objectives. They mentioned that the project aims to develop a competitive alternative to commercial Li-ion batteries, which could help reduce battery and EV costs.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that PNNL is a very strong national laboratory with excellent resources and expressed confidence that they should be able to achieve and meet all the milestones.

Reviewer 2:

The reviewer remarked that the project team appears to have sufficient resources to carry out the proposed research in a timely fashion.

Reviewer 3:

The reviewer commented that the project appears to be adequately funded to complete the proposed tasks successfully.

Reviewer 4:

The reviewer affirmed that the resources are sufficient for the project to achieve its stated milestones.

Presentation Number: BAT456
Presentation Title: eXtreme Fast Charge Electrode and Cell Design Thrust
Principal Investigator: Andrew Jansen (Argonne National Laboratory)

Presenter

Andrew Jansen, Argonne National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

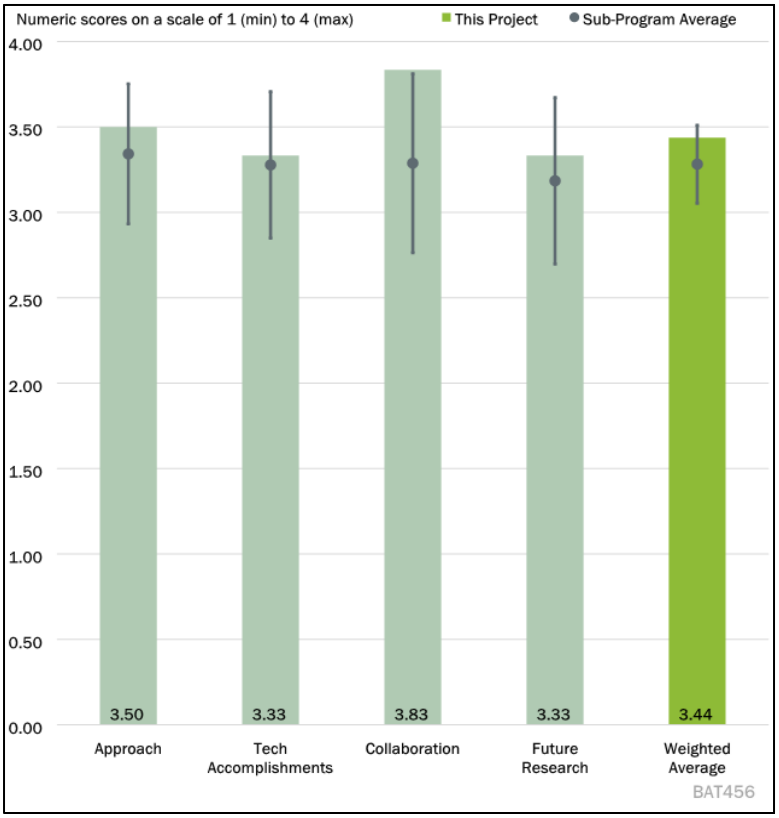

Figure 1-20 - Presentation Number: BAT456 Presentation Title: eXtreme Fast Charge Electrode and Cell Design Thrust Principal Investigator: Andrew Jansen (Argonne National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer stated that the project addresses major technical barriers for fast charging, including cell and electrode design, and has employed some effective characterization techniques. They noted that the research of the project is in alignment with DOE goals.

Reviewer 2:

The reviewer remarked that studying electrode structures to design them specifically for XCEL has been one of the enablers across the battery community. They found it interesting to see the achievements in making large-scale layers and structured electrodes. They also pointed out that tomography studies to understand ion concentration in these structured electrodes complement the better design of these electrodes. However, they emphasized that further development of these methods is critical in identifying the mechanisms when these electrodes are cycled. Additionally, the reviewer suggested that cost analysis of developing these structured electrodes should be part of the study.

Reviewer 3:

The reviewer noted that this project under XCEL addresses the challenge from the electrode architecture. They described the design of a layered structure, with a more porous part next to the separator and a denser part next to the substrate. They highlighted that the more accessible porosity allows for better ion transport under high drain rates.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer observed that a lot of good research has been achieved in this project and highlighted the detailed study conducted on both the anode and cathode potentials during XFC. They suggested that state of charge (SOC) be included in future presentations or studies (if not already planned), as it is unclear if the battery could be charged to 80% after completing XFC in the test.

Reviewer 2:

The reviewer commended the achievement of making these electrodes in large scale to create pouch cells. However, they pointed out the need for more pre-validation tests of the proposed characterization techniques and emphasized the importance of studying how these techniques are affected by the special structured electrodes in detail.

Reviewer 3:

The reviewer praised the technical approaches used in the project, noting that the new electrode, as shown by tomography, indeed possesses the designed architecture. They also mentioned that the final performance in the LIB cell exhibits certain improvement.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer commented on the organization and collaboration within the project team. The reviewer stated that the team, which consisted of researchers from several closely collaborated organizations, is well-organized.

Reviewer 2:

The reviewer remarked that the collaboration and coordination across the project teams are outstanding.

Reviewer 3:

The reviewer noted that the project was carried out in a highly collaborative manner.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer remarked that the future work illustrated is sound. They noted that it is unclear if the cell size affects charging current distribution during XFC performance and suggested that it might be interesting to use big size cell(s) for a comparison study.

Reviewer 2:

The reviewer commented that the proposed future work is in line with the overall scope of the project. They emphasized that identifying degradation mechanisms as the various enablers are studied is critical for success and suggested that future work should include a deep dive into these techniques and how they are affected by the structured electrodes.

Reviewer 3:

The reviewer stated that the proposed future pathway seems to be viable.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer stated that this project is a direct support to DOE goals.

Reviewer 2:

The reviewer commented that this project is extremely relevant to adoption of electrification on a large scale.

Reviewer 3:

The reviewer noted that this project is highly relevant to fast charge efforts.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer affirmed that the funding level seems appropriate for this project.

Reviewer 2:

The reviewer expressed that the funding planned for this project is sufficient to achieve the proposed goals.

Reviewer 3:

The reviewer stated that the resources are sufficient for the project.

Presentation Number: BAT463
Presentation Title: eXtreme Fast Charge Electrochemical and Thermal Performance Thrust
Principal Investigator: Eric Dufek (Idaho National Laboratory)

Presenter

Eric Dufek, Idaho National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

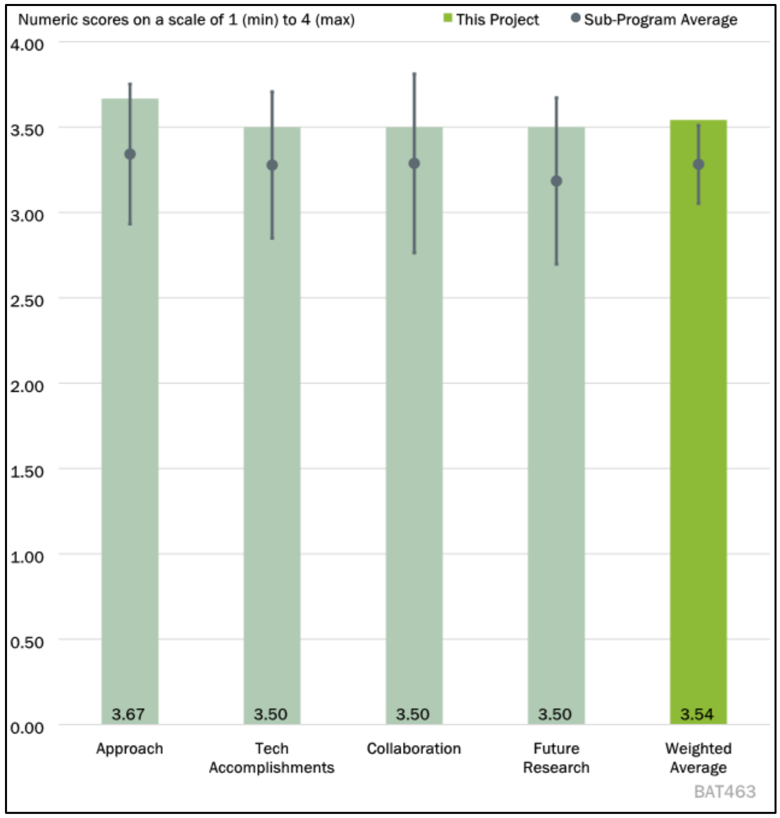

Figure 1-21 - Presentation Number: BAT463 Presentation Title: eXtreme Fast Charge Electrochemical and Thermal Performance Thrust Principal Investigator: Eric Dufek (Idaho National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer praised that the technical barriers are well addressed, and they appreciated the interesting progress made on XFC limitations in this project.

Reviewer 2:

The reviewer emphasized that developing a thermal strategy specific for fast charging is very critical. They also highlighted that the team's plans to use ML to understand the enablers and their effects on cycle life are critical for understanding the project's goals.

Reviewer 3:

The reviewer commented that this approach integrates the new electrolyte and dual-layer electrode work performed by the other two approaches and studies how an advanced charging protocol could manage the thermal effects of the LIB under fast charge conditions.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer stated that the approach to perform the work is appropriate, and they found the progress for year 1 impressive. They mentioned that the proposed milestones were met.

Reviewer 2:

The reviewer expressed that the scorecard proposal is excellent. However, they noted that since a multi-level comparison is presented, it is sometimes difficult to follow. They suggested that thermal strategies need to continue to track vehicle constraints. While acknowledging that the study focuses on ideal conditions, they suggested adding remarks about how close or far it is from real implementation.

Reviewer 3:

The reviewer remarked that the approaches led to certain improvements in LIB performances under fast charge. However, they pointed out that cathode degradation and Li^0 deposition are still observed.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer stated that the contractor has good collaboration among team members. They suggested that it would be better if the contribution from each team member could be detailed.

Reviewer 2:

The reviewer expressed that the collaboration and coordination across the project teams are outstanding.

Reviewer 3:

The reviewer noted that the PI has been working in a highly collaborative manner with other national laboratories in the project.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer commented that the proposed future study is reasonable.

Reviewer 2:

The reviewer remarked that the proposed future work is in track to the overall scope of the project. They emphasized that identifying the degradation mechanism as the various enablers are studied is critical for success.

Reviewer 3:

The reviewer stated that the proposed direction focuses on the new electrolyte, which is undoubtedly correct.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer stated that the project supports DOE goals by studying to understand XFC limitations and polarization and mechanical impacts of rapid transitions from discharge-charge-discharge across SOC windows.

Reviewer 2:

The reviewer commented that this project is extremely relevant to the adoption of electrification on a large scale.

Reviewer 3:

The reviewer affirmed that the project is highly relevant.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer affirmed that the funding level is appropriate for the scheduled work.

Reviewer 2:

The reviewer expressed that the funding planned for this project is sufficient to achieve the proposed goals.

Reviewer 3:

The reviewer verified that the funding is sufficient.

Presentation Number: BAT470
Presentation Title: Process R&D Using Supercritical Fluid Reactors
Principal Investigator: Youngho Shin (Argonne National Laboratory)

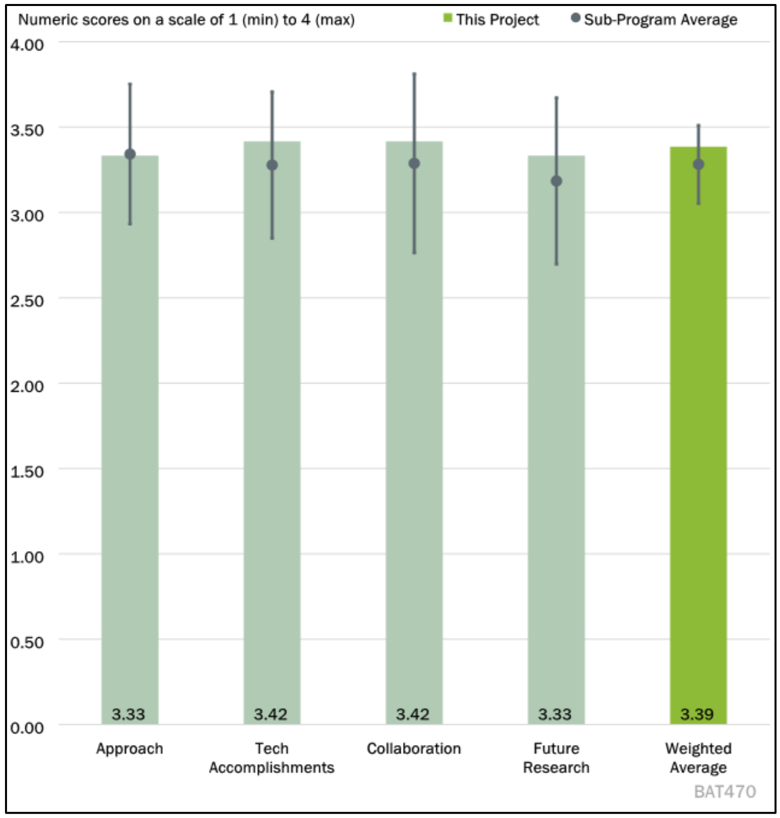

Figure 1-22 - Presentation Number: BAT470 Presentation Title: Process R&D Using Supercritical Fluid Reactors Principal Investigator: Youngho Shin (Argonne National Laboratory)

Presenter

Youngho Shin, Argonne National Laboratory

Reviewer Sample Size

A total of six reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer expressed that this is another important BAT project at ANL that emphasizes battery materials synthesis. They found the study on hydrothermal synthesis under sub or supercritical conditions to be a unique research thrust with great potential. They noted that the successful development of the hydrothermal synthesis approach could help reduce the cost and environmental impact of CAM production while creating novel materials with properties and morphology that cannot be reached with conventional approaches.

Reviewer 2:

The reviewer raised doubts about whether the supercritical hydrothermal (SCHT) approach does better than conventional processing approaches. They pointed out that the cycle life data shown on Slides 8 and 10 could be better and that commercial 811 cells last many thousands of cycles. They suggested that perhaps the measurements were taken on relatively poor electrodes and may not reflect the inherent quality of the active material.

Reviewer 3:

The reviewer noted that the PI’s program is dedicated to advancing the methodology and instruments used in the fabrication of single crystal CAMs, emphasizing the criticality of supporting R&D and instrumentation efforts at DOE facilities. They highlighted the significance of the supercritical point manufacturing approach, which is typically financially inaccessible for university investigators.

Reviewer 4:

The reviewer emphasized that transitioning from a traditional CSTR to a faster economical process is critical for the large-scale mass adaptation of LIBs. They acknowledged that this project aims to achieve this goal.

Reviewer 5:

The reviewer mentioned that the timeline for 2022 has been completed and that the continuous flow subcritical hydrothermal process allows cathodes to be tested and mass-produced for industries to reduce their costs. They suggested adding tests of cathodes made from materials other than Ni, Co, and Mn to the project.

Reviewer 6:

The reviewer concluded that, for the current funding levels, the team's focus and the scale of the work are appropriate. They appreciated the comparisons of the three different processes and their impacts on single crystal CAMs. They noted that the range and scale of the different materials produced and studied is quite an undertaking.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer remarked that in FY 2022, the project undertook the commissioning of the continuous-flow supercritical hydrothermal system and carried out the synthesis of monocrystalline NMC811 using conventional co-precipitation CSTR. In 2023, they synthesized single-crystal cathode material cg-$LiFePO_4$ (cg-LFP) through the newly constructed continuous-flow supercritical hydrothermal system. The reviewer observed that the team also conducted structural and morphological characterizations, collaborating with other teams on these materials, including SEM, XPS, Bragg coherent diffraction imaging (BCDI), and *in situ* synchrotron XRD.

Reviewer 2:

The reviewer expressed the view that significant progress had been achieved against the project's goals. A central concern raised by the reviewer was the ability to scale up the technique cost-effectively, given the necessity for very high-pressure and high-temperature operation. The reviewer questioned how the transition from 100-gram batches to tons could be managed.

Reviewer 3:

The reviewer affirmed that the PI's successful demonstration of the formation of single-crystal CAMs through three distinct approaches. These approaches included the traditional sintering method, the supercritical point synthesis of monocrystalline oxide preCAMs, and a continuous manufacturing approach. The reviewer observed that the second and third research directions represented highly innovative avenues with the potential to establish a solid foundation for the future commercialization of these novel fabrication technologies.

Reviewer 4:

The reviewer praised the presentation for its focus on an important aspect of battery research: new methods of cathode synthesis that could offer a cost advantage without compromising performance. However, the reviewer had a few comments and questions. The reviewer asked about the lower capacity of monocrystalline NMC compared to its polycrystalline counterparts on Slides 7 and 8, inquired about the influence of monocrystalline material synthesis at 920°C, and questioned whether any cation mixing had been observed. Additionally, the reviewer sought clarification on whether the polycrystalline material in the cycling performance comparison on Slide 10 had a surface coating. The reviewer also articulated the importance of extracting key takeaways from Slide 16 regarding diffraction contrast diffractive imaging (DCDI) for NMC811 from the three different synthesis methods.

Reviewer 5:

The reviewer verified that the team had successfully tested the three methods to produce monocrystalline cathodes, resulting in higher density, larger cycling capacity, reduced surface defects, and an improved surface coating effect. The reviewer also clarified that the project intended to explore different cathodes beyond NMC811, although the specific next cathodes had not yet been selected.

Reviewer 6:

In the reviewer's overall assessment, the processes and accomplishments of the project were deemed impressive, with a noteworthy emphasis on processing time. However, the reviewer suggested that future presentations could benefit from improved communication of the process operation. The reviewer emphasized that understanding the operation of the process was critical for reviewers and the general audience to better grasp the project's impact and results. Furthermore, the reviewer remarked that including comments on the safety of the new processing systems at scale would be beneficial, considering whether the same safety management practices at a pre-pilot scale would apply at larger scales or if adjustments would be necessary. The reviewer noted that this aspect might be more appropriate as a barrier or future work and might not be addressable within the current funding scope.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer noted that the project team has collaborations within ANL and BNL for various characterizations using their testing facilities, as well as with Hunt Energy for atomic layer deposition (ALD) Al_2O_3 surface coating.

Reviewer 2:

The reviewer expressed some confusion regarding the decision to coat LFP using ALD. Given that LFP is a low-voltage material, the reviewer did not expect any electrolyte instability in this context.

Reviewer 3:

The reviewer acknowledged the PI for establishing a robust team of collaborators to explore diverse mechanistic and structural aspects of single-crystal CAMs.

Reviewer 4:

The reviewer emphasized the importance of the project's collaborations, which range from universities to cathode manufacturers. The reviewer stressed that understanding the practical realities of mass production is crucial.

Reviewer 5:

The reviewer commended the project for clearly articulating the contributions of universities, national laboratories, and industry. The reviewer pointed out the project's goal to test more cathode samples and transform them from polycrystalline to monocrystalline, particularly cathodes that do not contain Ni, Mn, and Co. The reviewer encouraged expanding the range of materials for cathodes being tested by seeking additional ideas from industry partners.

Reviewer 6:

The reviewer highlighted the project's significance as addressing a missing link between the discovery of new battery materials, market evaluation of these materials, and high-volume manufacturing. While acknowledging the strong collaborations between universities and national laboratories, the reviewer expressed a desire to see more external input on the material and/or process in future years, with increased involvement from industry.

The reviewer acknowledged that industry may often hesitate to take on the financial risk associated with process scale-up and the development of materials that have not been validated. However, the reviewer stressed that incorporating more industry feedback early in the project could further advance the technology and reduce the DOE investment risk before reaching pilot and production scales.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer acknowledged that the team has clearly outlined their plans for future research, which are highly likely to be achieved. Among the listed remaining challenges and barriers, the most critical and relevant target was identified as systematic research on hydrothermal synthesis to optimize the structure and morphology of CAMs. The reviewer encouraged the team to investigate the hydrothermal process using *in situ* XRD and PDF techniques.

Reviewer 2:

The reviewer expressed difficulty in understanding how particle morphology could be controlled or changed using SCHT reactions. Given that the project is scheduled to conclude in September 2023, the reviewer concluded that there may be no need for further evaluation.

Reviewer 3:

The reviewer deemed the fabrication of single crystal Li metal rich (LMR) materials as having great significance, as LMR plays a crucial role in enabling cost-effective CAMs that can deliver high energy density per dollar spent.

Reviewer 4:

The reviewer acknowledged that the team's future work proposal is well-aligned with market needs, specifically highlighting particle morphology engineering and the development of the next-generation lithium iron phosphate ($LiFePO_4$) cathode material with Mn, referred to as LMFP.

Reviewer 5:

The reviewer expressed the need for more information regarding the purpose of future work. While noting that the team had achieved the proposed objectives, the reviewer believed it was very likely that they would achieve the objectives based on the proposed work.

Reviewer 6:

The reviewer noted that the project is set to conclude in September 2023, and commenting on future work is contingent on subsequent funding. If funded for FY 2024, the current future work plan was considered appropriate for addressing the remaining material challenges identified by the presenter. The reviewer suggested that, if funding permits, incorporating more feedback or input from additional industrial partners would be invaluable to the project.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer noted that the hydrothermal synthesis of CAMs represents a unique and effective approach for battery materials R&D, supporting the VTO objective in vehicle electrification.

Reviewer 2:

The reviewer expressed agreement with the relevance of the research efforts, emphasizing the importance of evaluating novel processing techniques. However, the reviewer also mentioned a desire to have seen a cost study conducted early in the project.

Reviewer 3:

The reviewer pointed out that the research efforts closely align with VTO's missions, particularly highlighting the advantages of single crystal CAMs in terms of longer cycle life due to their chemo-mechanical robustness. The development of novel, cost-effective, and scalable approaches for fabricating single crystal CAMs was deemed of immense importance for the US EV battery research community.

Reviewer 4:

Regarding specific questions and comments, the reviewer inquired about the lower capacity of monocrystalline NMC compared to its polycrystalline counterparts on Slides 7 and 8, the influence of monocrystalline material synthesis at 920°C, any observed cation mixing, and whether the polycrystalline material in the cycling performance comparison on Slide 10 had a surface coating. The reviewer also recommended extracting key takeaways from Slide 16 regarding DCDI for NMC811 from the three different synthesis methods.

Reviewer 5:

The reviewer emphasized that the project supports the analysis of batteries, energy-efficient mobility systems, and materials.

Reviewer 6:

In the reviewer's overall assessment, the project was deemed highly valuable and much-needed battery research, addressing a critical need for rapid material synthesis and continuous material production.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The project team has successfully commissioned the capabilities for the subcritical hydrothermal batch process and the supercritical hydrothermal continuous process. Additionally, they have established collaboration for materials and process characterization, and they possess sufficient resources to achieve the remaining milestones in a timely fashion.

Reviewer 2:

The reviewer expressed a positive assessment with a simple "Good."

Reviewer 3:

The reviewer pointed out the evident need for increased funding in FY 2023, considering the prevailing inflationary pressures impacting various aspects of research and development.

Reviewer 4:

The reviewer reiterated that the resources allocated to this project are deemed sufficient to achieve the project goals.

Reviewer 5:

The reviewer cited successful implementation of the continuous supercritical hydrothermal process and the batch subcritical hydrothermal process.

Reviewer 6:

The reviewer concluded that the resources appear sufficient for accomplishing the stated milestones, with the assumption that no major new equipment purchases or modifications are needed.

Presentation Number: BAT475
Presentation Title: Towards Solventless Processing of Thick Electron-Beam (EB) Cured Lithium-Ion Battery Cathodes
Principal Investigator: Zhijia Du (Oak Ridge National Laboratory)

Presenter

Zhijia Du, Oak Ridge National Laboratory

Reviewer Sample Size

A total of six reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

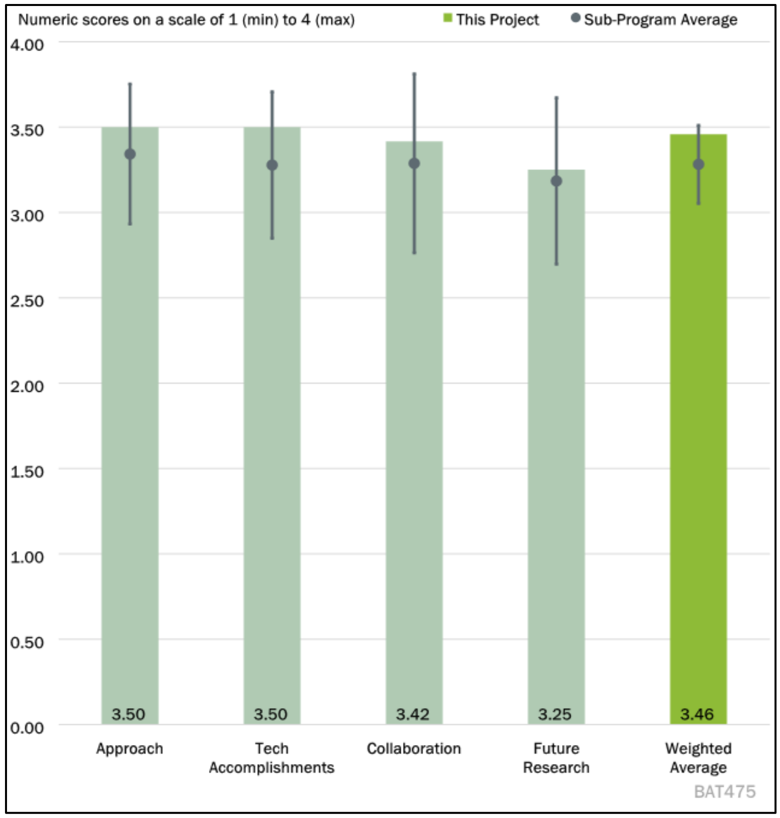

Figure 1-23 - Presentation Number: BAT475 Presentation Title: Towards Solventless Processing of Thick Electron-Beam (EB) Cured Lithium-Ion Battery Cathodes Principal Investigator: Zhijia Du (Oak Ridge National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer stated that the use of electron-beam (EB) technology to cure oligomers for electrode manufacturing, replacing the conventional slurry casting method, represents a novel approach to achieve solventless manufacturing of thick electrodes. It was acknowledged that EB technology allows for the production of ultra-thick electrodes due to its substantial penetration depth compared to laser or UV curing. However, the reviewer pointed out that the current approach, while reducing the need for liquid or solvent, has not achieved complete solventless manufacturing. The reviewer highlighted the necessity of developing new binder or polymer formulations to make the EB process viable, particularly for anode development.

Reviewer 2:

Regarding the project’s objectives, the reviewer remarked that the primary goal is to address the EV battery cost, aiming for a target of $60/kWh and a 1000-cycle life by optimizing material processing and increasing electrode thickness. However, the reviewer expressed some skepticism about achieving the cost target solely through the proposed work. Additionally, the reviewer noted that the project’s duration of six years appears relatively long compared to regular DOE projects.

Reviewer 3:

The reviewer observed that a low-cost, solvent-free process for fabricating thicker cathodes has been developed and tested. The potential of a solid-state Li battery with a polymer electrolyte through an EB-cured polymer membrane and a polymer/LFP composite cathode was recognized as a promising approach. However, the reviewer also pointed out that several challenges remain to be addressed.

Reviewer 4:

The reviewer verified that EB cure technology was successfully demonstrated for Li-ion batteries, achieving the principal objective of establishing an EB curing capability at ORNL. However, the reviewer expressed curiosity about the use of solvents in achieving desired coatings and sought more information regarding its necessity, volume used, solvent type, and whether the coating line includes a drying zone upstream of the EB curing module. The reviewer also inquired about achievable line speeds, limitations, depth-of-cure concerns, and cure dynamics. Furthermore, the reviewer asked if there were any issues with binder not being fully cured, leaving low molecular weight components in the electrode.

Reviewer 5:

In summarizing the project’s scope, the reviewer articulated that it is well-designed for addressing technical barriers and commended the team for effectively presenting Phase 1–3 goals. However, the reviewer suggested that the project could benefit from further explanation of how EB curing will lead to the targeted $60/kWh cost reduction, potentially through modeling or process extrapolation. The project was praised for its well-designed focus on achieving low-cost, long cycle life, high-power cells.

Reviewer 6:

The reviewer found the project to be well designed and sharply focused on the low-cost production of long cycle life high power cells.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer noted that the manufacturing of NMC and LFP cathodes using EB curing has been successfully demonstrated. In the case of LFP cathodes, the use of CNTs to reduce carbon additives was found encouraging, although the reviewer suggested that further reduction of binder content may be needed to meet industrial requirements. The reviewer suggested that it would be beneficial to conduct a direct comparison with slurry-casted thick electrodes (using PVDF) concerning mechanical properties (following industrial standards) and electrochemical properties to benchmark the performance of EB cured electrodes and demonstrate their advantages. Additionally, there was a question raised about the uniformity of the coating and whether the minimum liquid/solvent used might affect coating uniformity.

Reviewer 2:

The reviewer acknowledged the project’s good technical progress and its execution in five phases, each addressing specific aspects of EB curing technology. However, the reviewer expressed some difficulty in assessing the current year’s results due to incomplete information and improperly labeled graphs, making it challenging to interpret data related to current vs. voltage and capacity vs. cycling. The reviewer questioned whether the modest improvement achieved with CNTs justified the cost of their use and expressed interest in knowing what analysis would be conducted to identify the failure mechanism for the EB-cured polymer.

Reviewer 3:

While noting that some major milestones had been achieved, the reviewer expressed interest in learning more about the challenges overcome and potential compromises made during the project, such as the use of solvent.

The reviewer suggested that providing a historical perspective on EB curing for battery electrodes would be informative, offering insights into its previous use and success in electrode manufacturing.

Reviewer 4:

The reviewer appreciated the team's demonstration of the compatibility of the EB process with NMC and LFP systems, as shown by the cycling and capacity retention data. The addition of CNTs to reduce inactive materials was commended, and the reviewer expressed anticipation regarding the analysis of failure mechanisms in pouch cells. However, the reviewer pointed out that there was no mention of cathode loading in the data and requested more information on processing conditions, excluding proprietary details.

Reviewer 5:

In the reviewer's assessment, the project was progressing well according to the plan, with significant improvements in resin selection and the use of CNTs and carbon black blends for cathodes. While acknowledging that cycle life tests of pouch cells were ongoing, the reviewer noted improvements observed in early-stage results and emphasized their importance, even though some solvent had been used during electrode processing.

Reviewer 6:

The reviewer stated that the overall processes and what the authors have accomplished are impressive. The processing time is also impressive. One item which could be improved upon in future presentations is better communicating the process operation. The reviewer stated it was not fully clear how the process worked or operated and that is critical for a reviewer to understand to put the materials and their results in better context. The presentation focused on material results and performance but a clearer presentation on how the process works would help reviewers and the general audience better understand the impact of the project as well as its overall results. The reviewer believed this would also be appreciated by industry if the goal is to eventually transition this technology to a larger scale. The reviewer also felt safety of the new processing systems at scale would also be helpful for industry. The reviewer inquired whether the same safety management at a pre-pilot scale would also apply at larger scales or do things change? This might be more appropriate to note as a barrier or future work and is not something that can likely be addressed with the current funding.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer emphasized the importance of expanding collaboration beyond equipment suppliers, material suppliers, and battery manufacturers to include EV companies that may be interested in adopting solventless battery manufacturing technology. The reviewer noted that many EV companies have shown a keen interest in evaluating and adopting such technologies recently.

Reviewer 2:

While acknowledging the collaboration with equipment suppliers, battery manufacturers, and raw material suppliers, the reviewer expressed some confusion about how these suppliers are involved in the work due to the absence of a budget allocation for them.

Reviewer 3:

The reviewer commended the project for its industry collaboration.

Reviewer 4:

The reviewer recognized the vital role played by collaboration with EB equipment suppliers and raw material (binder) suppliers in the project's success. There was a specific inquiry about how the processing of the solvent-containing coating formulation was handled, including whether there was a retrofitting of a drying zone prior to EB cure on the coating line or if pre-drying of samples was done before passing them through the EB station. Long-term plans for modifications to the EB line to accommodate such formulations were also of interest.

Reviewer 5:

The reviewer expressed the desire for more information on how partners actively participate in the program and the extent of their involvement.

Reviewer 6:

The reviewer praised the project's well-coordinated efforts and the clear definition of roles and responsibilities among collaborators.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer observed that future work related to anode manufacturing has been identified; however, there is a lack of clarity regarding the clear path for developing anodes, particularly concerning potential adhesion issues. Additionally, reducing the binder amount for LFP cathodes is considered an important future task, but achieving a completely solventless process for LFP with low binder content may pose challenges.

Reviewer 2:

The reviewer pointed out that there will be over one year remaining until the project's completion and proposed specific areas for future research. The reviewer suggested that the team should prioritize focusing on producing industrial-quality electrodes that can be used in larger cells, as this is crucial for industry adoption of the technology. The areas of exploring radiation-curable binder formulations for the next generation of anode processes, studying LFP cathode loading and its EB process conditions for good electrochemical performance, and understanding the failure mechanism of EB/UV cured polymer electrolyte and catholyte in lithium metal batteries were all deemed important.

Reviewer 3:

In general, the reviewer noted that the proposed research appears to align with the project's original plans, although the development of EB-cured anodes seems to be a new objective. The reviewer highlighted a lack of clarity regarding how the failure mechanisms will be investigated.

Reviewer 4:

The reviewer expressed interest in the next objectives, such as achieving higher LFP loading, developing EB-cured anodes, and working on SSB technology, considering these areas as intriguing for exploration with the EB curing technology.

Reviewer 5:

The reviewer acknowledged the team's good understanding of current technical barriers, especially those related to LFP cathodes and anodes. However, the reviewer requested additional clarification and direction regarding how curable binder formulations and process conditions for anodes and LFP cathodes would be addressed.

Reviewer 6:

The reviewer recognized the challenging nature of achieving high-quality electrodes with a solventless process and noted that understanding the failure mechanisms behind Li metal polymer prototype cells would require significant effort to produce cells with satisfactory cycle life.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer highlighted the significance of developing solventless manufacturing of electrodes, emphasizing its potential to reduce the cost of EV battery manufacturing and increase energy density. The reduction in the footprint of electrode manufacturing equipment was noted as an additional advantage. The project’s ability to enable thick electrodes, thus reducing the amount of inactive material in the cell and material/manufacturing costs, aligns with the objectives of the VTO batteries subprogram.

Reviewer 2:

The reviewer affirmed that the project supports the broader objectives of the VTO battery program in terms of cost reduction.

Reviewer 3:

The reviewer underscored the project’s relevance to the development of thicker, low-cost cathode materials with good performance.

Reviewer 4:

The reviewer found a strong emphasis was placed on the importance of investigating alternatives to the traditional n-methyl-2-pyrrolidone (NMP)-based coating method for lithium-ion cathode production. The limitations associated with NMP, particularly its evaporation speed and health and environmental concerns, make alternatives that address these limitations highly welcome.

Reviewer 5:

The reviewer deemed the program relevant to supporting the VTO subprogram objectives for batteries, specifically in terms of decarbonizing the battery supply chain through the use of EB processing instead of traditional slurry casting, reducing the cost per kilowatt-hour ($/kWh) of batteries, and enabling next-generation cell chemistries.

Reviewer 6:

While recognizing the solventless EB-cured Li-ion cathode as an enabling technology for low-cost electrode production that aligns with the VTO subprogram objectives, the reviewer suggested that the electrode EB processing might be further controllable when using a limited amount of environmentally friendly solvent.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that the team has sufficient resources to perform the proposed research and achieve the stated milestones.

Reviewer 2:

The reviewer remarked that, indeed, the team has enough resources to conduct the proposed research. The reviewer also suggested involving companies in the project as early as possible.

Reviewer 3:

The reviewer observed that the resources appear to be adequate.

Reviewer 4:

The reviewer questioned whether equipment modifications were needed to handle formulations containing solvents and whether the necessary resources and funding were available for this purpose. The reviewer noted that this aspect was not presented, leaving it unclear if it is still an issue or already addressed.

Reviewer 5:

The reviewer affirmed that, based on the results, the resources provided are sufficient, and the team seems to be on track to meet their stated milestones in a timely fashion.

Reviewer 6:

The reviewer expressed the opinion that the resources are sufficient for the project to achieve the stated milestones on time. Additionally, the reviewer suggested that more collaborators from industry may be needed to expedite progress in high-speed electrode preparation.

Presentation Number: BAT524
Presentation Title: Advanced Electrolytes for Li Metal Batteries
Principal Investigator: Chunsheng Wang (University of Maryland)

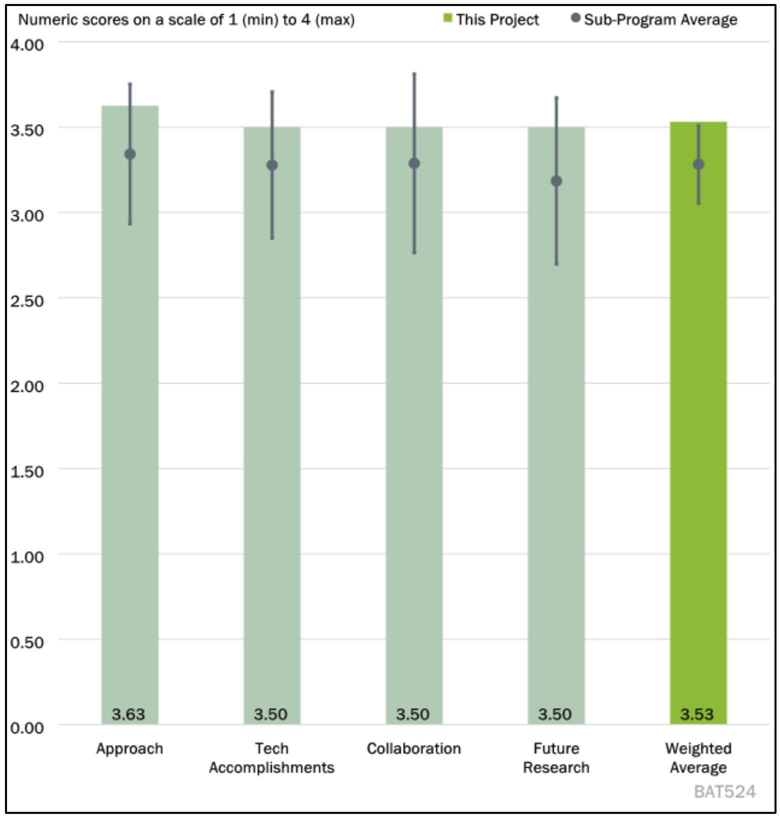

Figure 1-24 - Presentation Number: BAT524 Presentation Title: Advanced Electrolytes for Li Metal Batteries Principal Investigator: Chunsheng Wang (University of Maryland)

Presenter

Chunsheng Wang, University of Maryland

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer praised the team's aim to develop high-energy Li-metal batteries and acknowledged the challenge of forming a LiF interphase to passivate interfaces between Li metal anode and high-energy NMC811/SPAN cathode, inhibiting dendrite growth and cathode penetration by the liquid electrolyte. The reviewer noted that the team addresses this challenge by designing and using solvent-free ionic liquid electrolytes, promoting anion reduction for LiF formation, and suppressing solvent reduction that could lead to unwanted organic-inorganic interphases. The reviewer found these approaches effective and promising.

Reviewer 2:

The reviewer expressed overall satisfaction with the approach, considering it excellent and with very promising results.

Reviewer 3:

The reviewer highlighted the team's focus on electrolyte design for Li-metal/NMC or SPAN cathodes to achieve longer cycle life and capacity retention. The project's utilization of modeling input on various liquid electrolyte formulations, with the goal of developing a robust cathode electrolyte interphase (CEI), particularly for NMC811 and sulfur-based cathodes, was acknowledged. The reviewer appreciated the use of density functional theory (DFT) and molecular dynamics-based calculations to determine the energies and stability of electrolyte (solvent and salt) decomposition at both cathodic and anodic interfaces, providing a good design of experiments for robust solid electrolyte interphase (SEI) and CEI.

Reviewer 4:

The reviewer recognized the PI's aim to address interphase stability issues in full-cell Li-metal batteries using NMC as the cathode and Li metal as the anode. The approach of designing advanced electrolytes capable of producing the desired interphases, with LiF identified as a key component, was noted. The reviewer highlighted LiF's high oxidation stability on the cathode side and its ability to suppress vertical Li dendrite growth and promote Li migration along the LiF/Li interface on the anode side.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer provided an overview of the project's milestones for FY 2023, noting that one milestone, achieving high CE and cycle numbers for SPAN/Li, has been completed. Another milestone, testing the designed electrolytes for NMC811/Li, is ongoing. Three of the five milestones are still on track, with the reviewer emphasizing the need for testing collaborations for the University of Washington (UW) and INL.

Reviewer 2:

The reviewer stated that the approach is excellent, with very promising results.

Reviewer 3:

The reviewer highlighted several outstanding accomplishments of the PI and the team:

Electrolyte design for stabilizing high voltage NMC cathode: The team achieved FSI-derived LiF interphases on both the Li anode and NMC811 cathode, effectively suppressing Li dendrites and preventing electrolyte penetration into cracked NMC811. This enabled a 4.5 mAh/cm² NMC811/Li cell to achieve 200 cycles at a wide cutoff voltage range of 2.8V–4.7V, cycling at a rate of 0.3C and with a lean electrolyte of 5 g/Ah.

Electrolyte design for SPAN cathode: The use of ether electrolytes promoted the formation of inorganic LiF-rich SEI with a Li, CE of greater than 99.4% at 0.5 mA/cm² and a capacity of 4.0 mAh/cm² for SPAN cathodes. The achieved high CE and cycle numbers for SPAN/Li (CE greater than 99.9%, more than 200 cycles) using SPAN cathodes supplied by the Idaho National Laboratory were noted.

The reviewer emphasized that their study concluded that FSI-derived LiF interphases on both the Li anode and cathodes effectively suppressed Li dendrites and prevented electrolyte penetration into the cathode, providing high-capacity retention at higher anodic voltages.

Reviewer 4:

The reviewer acknowledged the significant progress made by the PI's team, particularly regarding anodeless pouch cells and NMC811||Li cells. They highlighted that the ionic liquid electrolyte enabled stable cycling of a 30 mAh Cu||NMC811 pouch cell with 2 mAh/cm² loading, maintaining over 80% initial capacity after more than 300 cycles under lean electrolyte conditions. Similarly, the carbonate electrolyte enabled stable cycling of a coin cell with 4.5 mAh/cm² loading in the voltage range of 2.8V–4.7V, maintaining more than 80% of the initial capacity for over 200 cycles. The reviewer noted that characterization results would be needed to support the claim that LiF is the key interphase component stabilizing both NMC/SPAN cathode and Li metal anode.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer acknowledged the team's collaborations with various institutions, including the University of Washington (UW), INL, BNL, the Army Research Laboratory (ARL), and SAFT. The ongoing collaborations with UW and INL for testing the designed electrolytes and Li/NMC and Li/SPAN cells were noted. The reviewer also mentioned that the poster might not contain enough collaborated results with ARL on the simulations of solvation structures, likely due to space limitations.

Reviewer 2:

The reviewer praised the excellent collaboration.

Reviewer 3:

The reviewer described the teamwork and collaboration within the team as excellent, as evidenced by the technical accomplishments. The reviewer specifically praised the collaboration with ARL, highlighting its value in guiding research directions.

Reviewer 4:

The reviewer noted that the PI has extensive collaborations with national laboratories and industry, underscoring the collaborative nature of the project.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer acknowledged the proposed future work, which includes further characterization of the newly developed electrolytes and cell optimizations. The reviewer suggested that it would be even better if more details could be provided on the simulation aspect of the research and how it can enhance electrolyte design and cell performance in conjunction with experiments. Specific questions raised included how the LiF interphase is formed by promoting the reduction of fluorinated salts, possible reaction mechanisms, and how the formation of other interphases is suppressed.

Reviewer 2:

The reviewer stated that the proposed future research is excellent.

Reviewer 3:

The reviewer praised the team's clearly defined goals and metrics for future research. They noted that the team intends to continue characterization and performance testing of their new electrolytes on Li-metal and high-capacity (and voltage) cathodes to meet the VTO battery targets. The development of electrolyte compositions that can lead to the formation of stable SEI and CEI with high CE was seen as an acceleration of R&D in this field.

Reviewer 4:

The reviewer acknowledged the PI's proposal to carry out more characterizations for the developed systems as the next step. The proposal to optimize cell parameters for even better electrochemical performance was also noted and considered appropriate.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer emphasized that the project aligns very well with the VTO objective, which is to achieve high-energy Li-metal batteries with a long cycle life.

Reviewer 2:

The reviewer described the project as highly relevant to this objective.

Reviewer 3:

The reviewer pointed out that the project goals are in alignment with VTO's battery R&D performance targets, specifically aiming for 500 Wh/kg with 1000 deep cycles. The reviewer noted that the team's aim to demonstrate these results in a 5–10 Ah pouch cell format demonstrated scalability.

Reviewer 4:

The reviewer noted that the project was relevant to the B500 Consortium's focus on developing new electrolyte systems to support Li metal batteries. This is a significant contribution to the project's relevance to VTO's subprogram objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that based on the progress of the project, the current resources are deemed sufficient and appropriate to reach the set milestones on time.

Reviewer 2:

The reviewer described the resources as sufficient.

Reviewer 3:

The reviewer mentioned that the project is funded at an appropriate level, allowing it to meet the deliverables as required.

Reviewer 4:

The resources for the project were assessed by the reviewer as sufficient to achieve the stated milestones in a timely fashion.

Presentation Number: BAT528
Presentation Title: Structurally and Electrochemically Stabilized Silicon-rich Anodes for Electric Vehicle Applications
Principal Investigator: John Thorne (Enovix)

Presenter

John Thorne, Enovix

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

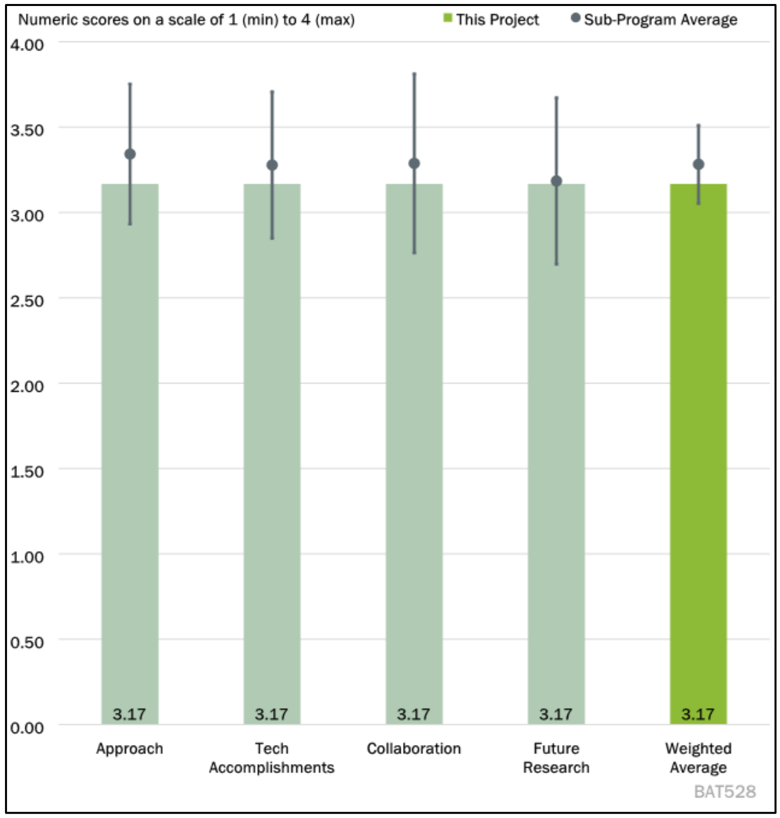

Figure 1-25 - Presentation Number: BAT528 Presentation Title: Structurally and Electrochemically Stabilized Silicon-rich Anodes for Electric Vehicle Applications Principal Investigator: John Thorne (Enovix)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer remarked that a cycle life of 1000 cycles had been achieved for all presented combinations of the low/high loading and [unspecified] pressures. Nonetheless, it remained unclear how much the pressure system added to the weight/volume of the pack, and whether the modeled approximate 270 Wh/kg energy density in the 100 Ah size included the pressure system or not. Additionally, there was ambiguity on how the proposed approach intended to meet the program target of 350 Wh/kg of specific energy. Another point of obscurity was why high loading (lower electrolyte to cathode ratio) data was presented only up to 2 months, making it difficult to extrapolate/estimate calendar life for 4.2V needed to reach 270 Wh/kg. The reviewer expressed hope that the 3 Ah cells to be built in FY 2023 would provide more reliable data.

Reviewer 2:

The reviewer noted that Enovix's utilization of 100% active silicon (Si) was quite impressive. However, it was unclear whether the projected values reported for nickel manganese cobalt 622 (NMC622) and nickel manganese cobalt 811 (NMC811) were core volumetric energy density (VED) or packaged VED.

Reviewer 3:

In the assessment of the overall presentation, the reviewer observed that it was very good, and the technical barriers being addressed were clearly indicated. However, what remained unclear was whether the project intended to meet all or part of the goals.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer stated that the presented data indicated significant progress in the evaluation of the proposed technology. However, it was acknowledged that there were limitations to the approach, which would reach only 270 Wh/kg, a value notably lower than the 350 Wh/kg program target.

Reviewer 2:

Regarding the cycling performance, the reviewer regarded the achievement of 1000 cycles to about 90% capacity retention as quite good. The reviewer suggested presenting the data at a higher resolution scale to facilitate the clear observation of differences due to loading and pressure. There was also praise for the impressive calendar life, but a request for clarification whether it pertained to storage life or followed the USABC calendar life test procedure. Furthermore, the reviewer suggested including specific timeframes (month and year) in the milestone table, as the current notation of “on track” lacked specificity.

Reviewer 3:

In evaluating the overall project, the reviewer acknowledged its success but expressed concerns about its ability to meet most of the target goals outlined in the Program. Despite this, the performance was deemed convincing. The reviewer suggested that the presentation could have been enhanced by illustrating the starting point of the program and the current status to better showcase the progress made.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer noted that NREL had participated in the modeling and cell design efforts.

Reviewer 2:

The reviewer asserted that NREL was the right partner for conducting modeling work in collaboration.

Reviewer 3:

The reviewer pointed out that it was not clear which parts of the presentation were contributed by NREL. To enhance clarity, the reviewer recommended adding a small footnote on the appropriate tables and plots to indicate NREL’s involvement and contributions.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer stated that the proposed BP3 cell (3 Ah) appeared promising for providing more reliable and realistic estimates of both calendar and cycle life. However, the reviewer noted that no research plans had been presented that would further enable an increase in energy density beyond 270 Wh/kg to meet the program target.

Reviewer 2:

The reviewer acknowledged that fabricating and testing the 3 Ah cell was a commendable future work plan. To enhance understanding, the reviewer requested details on how Enovix cell architecture enabled pre-lithiation and inquired whether the cells tested thus far in this program had been pre-lithiated.

Reviewer 3:

The reviewer expressed anticipation for future data to support the model and encouraged additional calendar test work as a valuable component of the research.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer affirmed that this project aligned with the VTO subprogram objectives, indicating a clear alignment with VTO's goals. However, the reviewer pointed out that the project fell short of achieving the target energy density.

Reviewer 2:

The reviewer noted that this project was directly related to the Batteries subprogram objective within the broader context of VTO's overarching objective.

Reviewer 3:

In assessing the project's achievements, the reviewer highlighted that it demonstrated the feasibility of utilizing a pure Si anode successfully. However, the question of calendar life had not yet been fully addressed, and resolving this aspect would enhance the program's relevance and significance.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that the resources are adequate for the planned work.

Reviewer 2:

The reviewer commented that the resources are sufficient.

Reviewer 3:

The reviewer stated that there were no issues on this project, and none were mentioned by the research team.

Presentation Number: BAT529
Presentation Title: Rationally Designed Lithium-Ion Batteries Towards Displacing Internal Combustion Engines
Principal Investigator: Rick Costantino (Group 14 Technologies)

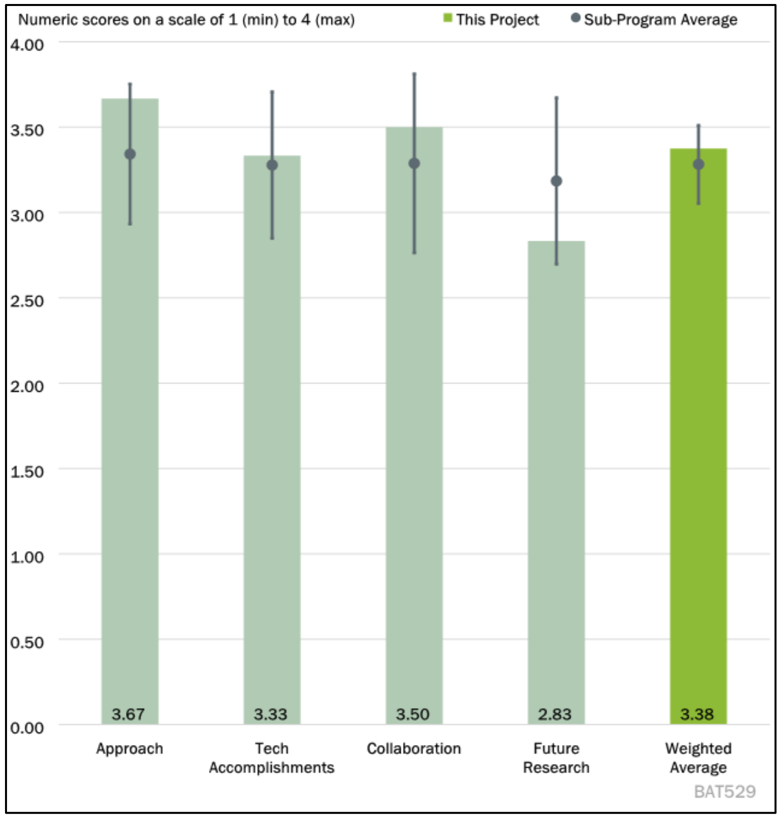

Figure 1-26 - Presentation Number: BAT529 Presentation Title: Rationally Designed Lithium-Ion Batteries Towards Displacing Internal Combustion Engines Principal Investigator: Rick Costantino (Group 14 Technologies)

Presenter

Rick Costantino, Group 14 Technologies

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer praised the overall development and commercialization approach presented, considering it excellent. In addition to the positive feedback, the reviewer suggested that it would be beneficial to include a mechanism for understanding calendar life degradation, examining aspects such as cell swelling over time, and exploring the dependence of calendar life on the cutoff voltage, cell energy density, and loading or the ratio of electrolyte to anode particle surface area.

Reviewer 2:

The reviewer commended the project for its well-designed structure and noted that it had been executed very well up to the current stage.

Reviewer 3:

The reviewer acknowledged that the project had been well-constructed, particularly in light of its objectives.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer affirmed that the presented data indicated a high probability of project success, suggesting optimism regarding the project’s outcomes.

Reviewer 2:

The reviewer acknowledged the excellent work and substantial progress made with respect to the project goals. It was noted that milestones had been consistently met within the promised timeline, which was considered commendable.

Reviewer 3:

Regarding progress, the reviewer remarked that it had been very good. However, there was a suggestion that expanding the scope of calendar life testing could enhance the ability to make more predictive outcomes based on the dataset.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer stated that while many partners were listed with their tasks, there was no demonstrated progress in each category that would allow for an evaluation of their contributions in each task. Specifically, the reviewer questioned how electrolyte optimization by Silatronix or binder optimization by Arkema had contributed to progress towards achieving the project's milestones.

Reviewer 2:

The reviewer affirmed that the partners involved in the project were among the best in their respective fields, particularly for components like binders, electrolytes, and conductive carbon. It was acknowledged that their expertise was critical for optimizing anode performance.

Reviewer 3:

The reviewer praised the project as a model of a well-organized and coordinated team. However, there was a suggestion that more transparent information on the contributions of individual partners to specific project tasks would enhance the overall understanding of progress and collaboration within the team.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer expressed that only limited details were presented to evaluate the question of protecting the Si-C anode from degradation while exposed to high temperatures at 100% state of charge. The only information provided was related to the "Suitability of test cells for calendar life evaluation methods." However, the reviewer asked for an elaboration on why the current cells were considered suitable for calendar life evaluation.

Reviewer 2:

The reviewer strongly recommended conducting cycle life tests using dynamic stress test (DST) type cycling, which closely resembles real-life vehicle requirements as outlined in the USABC test manual. Additionally, there was a suggestion to study the fast-charging capability of these cells. The reviewer also recommended measuring thickness expansion during both cycle and calendar life tests and observing the formation of gases to gain a better understanding of cell behavior.

Reviewer 3:

The reviewer expressed that it was not perfectly clear what specific actions were being taken to close the final target gap. To improve clarity, the reviewer suggested providing a more detailed description of the steps being taken to bridge this gap in achieving project objectives.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer stated that this project clearly aligned with and supported VTO objectives, spanning from materials development to cell fabrication and eventual commercialization.

Reviewer 2:

The reviewer noted that this project was directly related to the Batteries subprogram objective within the broader context of VTO's overarching objective.

Reviewer 3:

The reviewer affirmed that the development of a low-cost Si-carbon composite had the potential to be a key enabler for cost reduction, as well as a means to potentially reduce CO_2 emissions, highlighting the significance of this aspect within the project.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that there were adequate resources in place to accomplish the proposed tasks, indicating confidence in the resource allocation for the project.

Reviewer 2:

The reviewer remarked that the resources appeared to be sufficient for the remaining phases of the project, suggesting that there were no immediate concerns in this regard.

Reviewer 3:

The reviewer observed that the project boasted a well-balanced team, signifying that the team composition was deemed appropriate for the project's objectives and goals.

Presentation Number: BAT531
Presentation Title: Solid State Lithium-ion Batteries Using Silicon Composite Anodes
Principal Investigator: Pu Zhang (Solid Power Battery)

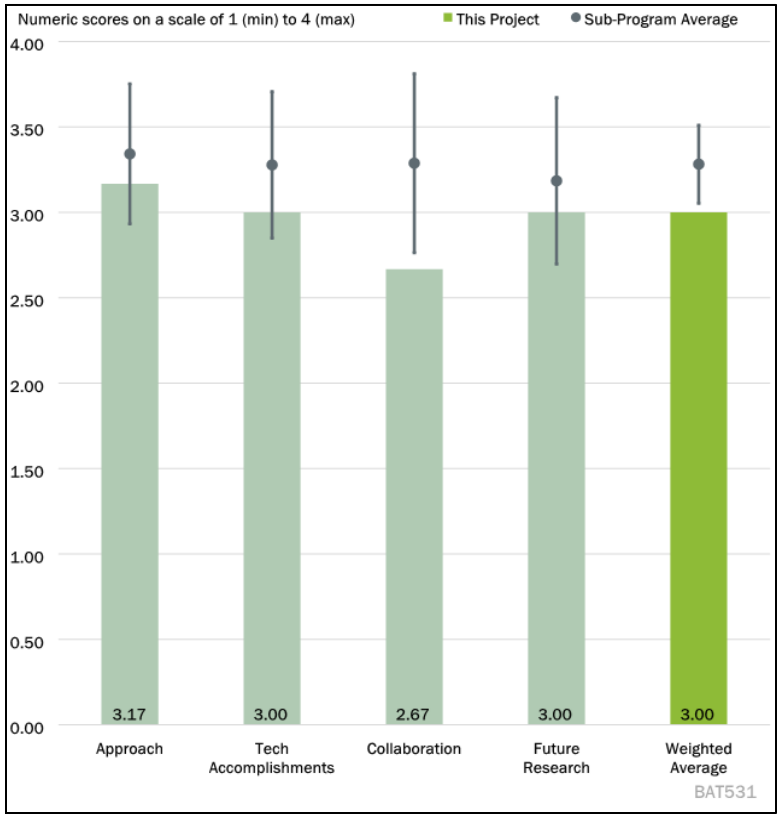

Figure 1-27 - Presentation Number: BAT531 Presentation Title: Solid State Lithium-ion Batteries Using Silicon Composite Anodes Principal Investigator: Pu Zhang (Solid Power Battery)

Presenter

Pu Zhang, Solid Power Battery

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 67% of reviewers felt that the resources were sufficient, 33% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer commented that a good approach had been presented, although there were some inconsistencies within the project documentation. Specifically, the reviewer highlighted an inconsistency in the response from the PI regarding electrode loading, where it was mentioned that electrodes with higher loading at 4 mAh/cm^2 had been developed in Year 2 to meet specific energy goals. However, the technical accomplishments on Slide 12 still showed results for 3 mAh/cm^2 cathode loading without specifying energy density or separator thickness. The reviewer inquired about the energy density for the cells presented on Slide 12, which achieved a cycle life of 800. Additionally, the reviewer pointed out that calendar life and impedance growth data had not been reported, making it difficult to assess progress and the likelihood of project success.

Reviewer 2:

The reviewer noted that the project was well-defined with clear goals and targets. There was a desire to see Solid Power study C-rates capability, including at lower temperatures.

Reviewer 3:

The reviewer stated that, overall, the project was in a very good state. However, the reviewer noted that the absence of work related to calendar life and cost modeling was noticeable.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer commented that good progress had been made toward increasing anode capacity and demonstrating cycle life. However, the reviewer noted that only initial calendar life had been evaluated, and there was no specification of the cell's energy density and size. Additionally, the overall energy density of the tested cells had not been reported. The reviewer had questions regarding the cycle life at room temperature and whether pressure had been applied during cycling.

Reviewer 2:

The reviewer praised the team for delivering milestones and meeting go/no-go decisions on time. There was hope expressed that the team would work on further improving first cycle efficiency above the current 91%. The reviewer also suggested considering the use of NMC811 cathode in future cell builds.

Reviewer 3:

The reviewer highlighted excellent progress in terms of cycle life and energy density. However, the reviewer pointed out that progress on calendar life and cost was noticeably absent and suggested that this aspect should be better illustrated within the project documentation.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer noted that no results, such as degradation mechanisms from ANL, had been reported, which made it challenging to evaluate if the collaborators had contributed to the project's success.

Reviewer 2:

The reviewer mentioned that there was no visible data or results emerging from ANL.

Reviewer 3:

The reviewer emphasized the importance of better illustrating the work products of ANL within the project's results and documentation.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer noted that the development of high-loading electrodes and testing of 2 Ah cells would be combined with impedance growth measurements and calendar life versus temperature assessments.

Reviewer 2:

The reviewer outlined several suggestions for the proposed future research plan:

Utilize ANL facilities and expertise to gain a better understanding of failure modes.

Consider studying cells with higher loading at 4.5 mAh/cm^2.

Measure cell thickness and pressure growth during and at the end of cycle life and calendar life testing.

Given that the project is scheduled to conclude by December 2023, it is essential to quantify performance at ambient temperatures, such as 25°C, and if possible, even at lower temperatures. This is important because all the data presented thus far has been at elevated temperatures of 45°C. Understanding cell capabilities at different temperatures is crucial.

Reviewer 3:

The reviewer emphasized the need to present work on calendar life and cost in addition to efforts to achieve a specific energy target of 350 Wh/kg while retaining cycle life. These aspects should also be a part of the project's focus and reporting.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer stated that the development of SSEs working with Si anodes clearly supports VTO subprogram objectives.

Reviewer 2:

The reviewer commented that this project relates well to the Batteries subprogram to support overall VTO objectives.

Reviewer 3:

The reviewer said that this is a high energy density project, enabling pure Si-anodes, which supports the overall goals of longer range and lower cost.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer expressed that there appeared to be sufficient resources allocated for the project, indicating no immediate concerns in this regard.

Reviewer 2:

The reviewer emphasized the need to utilize the resources at ANL to understand cell degradation mechanisms, as no results in that direction had been observed thus far.

Reviewer 3:

The reviewer raised concerns about the areas of calendar life and cost modeling, suggesting that unless demonstrated otherwise, there might be insufficient work being conducted in these specific areas. The reviewer highlighted the importance of addressing these aspects within the project.

Presentation Number: BAT532
Presentation Title: Electrolytes with Lithium-ion Batteries with Micro-sized Silicon Anodes
Principal Investigator: Chunsheng Wang (University of Maryland)

Presenter

Chunsheng Wang, University of Maryland

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

75% of reviewers felt that the project was relevant to current DOE objectives, 25% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 25% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

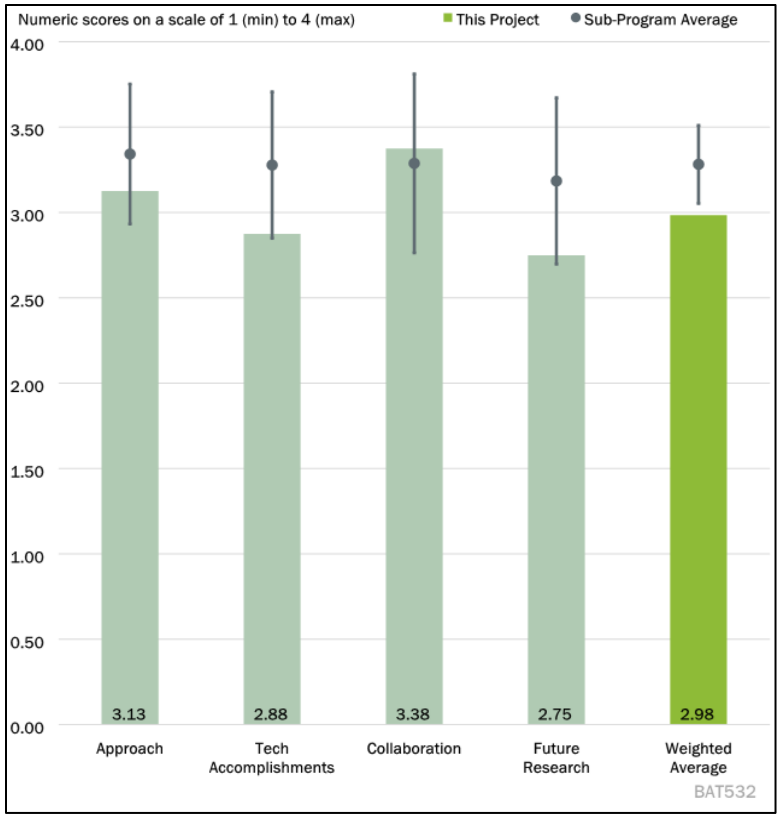

Figure 1-28 - Presentation Number: BAT532 Presentation Title: Electrolytes with Lithium-ion Batteries with Micro-sized Silicon Anodes Principal Investigator: Chunsheng Wang (University of Maryland)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer commented that the project was nearing completion and noted that the overall project planning had been presented well.

Reviewer 2:

The reviewer provided a technical assessment of the project, highlighting the use of anion-directed solid electrolyte interphase (SEI) with a high content of LiF-Li_2O for addressing the technical barrier, as well as the use of LiF for Si)-doped anodes in the formation of the CEI. The use of ionic liquid was mentioned as a potential approach to achieving different solvation properties. The reviewer pointed out the importance of considering the reactivity of Si and the solvent when determining the optimal SEI formula. The use of acronyms such as FST, FFT, and EE was mentioned in the presentation, and the reviewer recommended including the chemistry of the solvent choices in future AMR slides for clarity.

Reviewer 3:

The reviewer commended the project for being well-defined and praised the thoughtful approach of forming inorganics in SEI and CEI, particularly at decent loading levels of 4 mAh/cm^2.

Reviewer 4:

The reviewer also noted that the project was lacking a demonstration of the starting point and the improvements to be accomplished. Providing this context could enhance the understanding of the project's progression.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer noted that the project was focused on addressing the issue of unstable Si-anode SEI layers by designing a new electrolyte that forms a LiF-rich SEI. It was mentioned that the data obtained so far were comparable to the graphite baseline, and evaluations of full cells to meet the project target were in progress. However, the reviewer expressed a desire for more physical characterizations of the SEI layer on the micro-Si, even if these characterizations were part of earlier milestones.

Reviewer 2:

The reviewer acknowledged significant work on the plans for electrolytes and the performance of FST, which was identified as the best performer. Some minor comments and clarifications were provided, including the use of the term "volatile solvent-free" instead of "solvent-free" and the need for proper scale in leakage current measurements. The reviewer also questioned the counterintuitive increase in CE as the leakage current increased.

Reviewer 3:

The reviewer sought clarification on the acronyms FSE, FFT, and EE, assuming that they represented cells made with three different electrolytes. The reviewer recommended measuring thickness and pressure growth during cycling and calendar life for pouch cells. Additionally, there was a suggestion to improve cycle life, as 120 cycles to about 89% capacity retention were considered suboptimal.

Reviewer 4:

The reviewer found it challenging to discern progress in the project based on the presented information. The reviewer expressed a need for more key takeaways and emphasized the importance of clarity in project documentation.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer observed that each partner (UMD, ARL, Saft, SBU) appeared to have relevant and appropriate project tasks, reflecting a well-structured collaborative effort. While the reviewer expressed a desire to see more representation from collaborators on the poster, it was recognized that space constraints might have limited their inclusion.

Reviewer 2:

The reviewer noted that the team had a good combination of expertise, highlighting the diversity of skills and knowledge within the project.

Reviewer 3:

The reviewer praised ARL as an excellent collaborator for electrolyte modeling and related work, underscoring their valuable contribution to the project.

Reviewer 4:

The reviewer commended the project for clearly defining and demonstrating roles and responsibilities, which contributed to the overall organization and effectiveness of the collaboration.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer noted that the project was nearing completion and highlighted the focus of future work, which was to demonstrate good cycling and calendar life in multi-layer pouch cells.

Reviewer 2:

The reviewer commented that future plans were centered on pouch cells and aging mechanisms, as well as testing to understand different SOC and high-temperature performance.

Reviewer 3:

The reviewer pointed out that there were limited details provided about future work, with the statement merely indicating a "focus on modifying the cell configuration."

Reviewer 4:

The reviewer expressed skepticism about achieving the performance goals based on the information presented in the project documentation.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer stated that this project aligned with the DOE objective to achieve greater energy density in LIBs by introducing a stable form of Si into the anode.

Reviewer 2:

The reviewer noted that the project was relevant to VTO as it aimed to enable microsized Si anode technology.

Reviewer 3:

The reviewer sated that the project was primarily related to the VTO Batteries subprogram, supporting overall objectives of the VTO.

Reviewer 4:

The reviewer pointed out that while specific performance goals had been indicated, the project primarily aimed to better understand certain electrolyte phenomena in support of an SEI composition hypothesis. While some improvement in understanding had been achieved, a clear pathway to achieving the performance targets was not evident in the project documentation.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that resources appeared to be sufficient, expressing confidence in the adequacy of available resources.

Reviewer 2:

The reviewer affirmed that the resources were sufficient.

Reviewer 3:

The reviewer noted that the resources seemed sufficient to complete the stated goals of the project.

Reviewer 4:

The reviewer raised a concern, suggesting that if the performance goals were the primary objectives of the project, then the resources were insufficient to achieve those goals. This implied a potential misalignment between the goals and the available resources.

Presentation Number: BAT533
Presentation Title: Fluorinated Local High Concentration Electrolytes Enabling High Energy Density Silicon Anodes
Principal Investigator: Amy Marschilok (Stony Brook University)

Presenter

Amy Marschilok, Stony Brook University

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

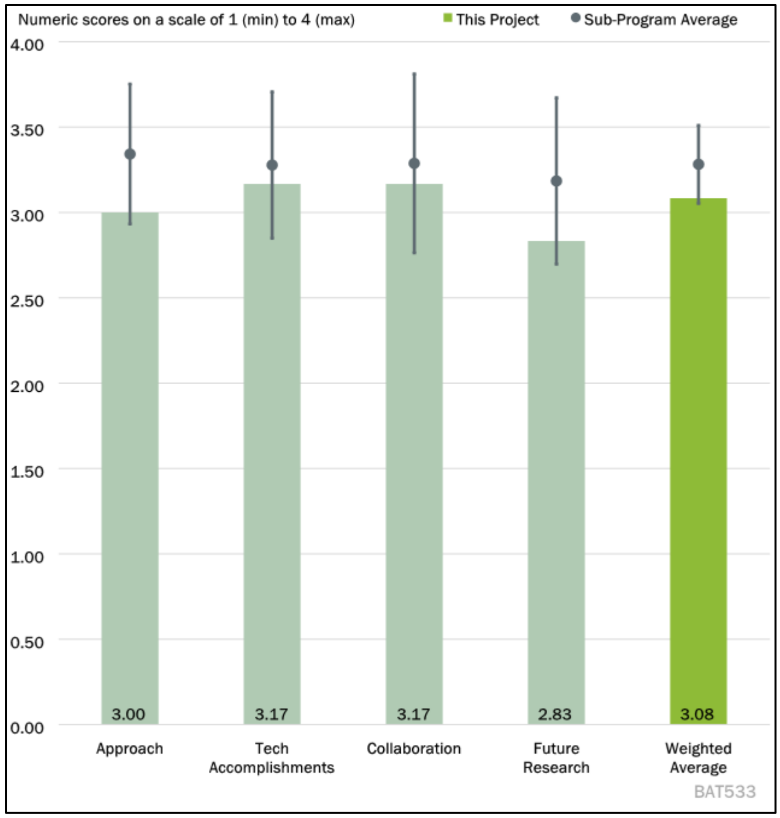

Figure 1-29 - Presentation Number: BAT533 Presentation Title: Fluorinated Local High Concentration Electrolytes Enabling High Energy Density Silicon Anodes Principal Investigator: Amy Marschilok (Stony Brook University)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer pointed out that the main metric of success, which was a 20% improvement in capacity retention over the baseline electrolyte (1M $LiPF_6$ EC/DMC + xFEC) with x ranging from 0% to 10% of fluoroethylene carbonate (FEC), could be misleading for two reasons. Firstly, the reviewer referenced the work of the Gasteiger group, which demonstrated that capacity retention is proportional to FEC consumption in this electrolyte. Thus, increasing FEC concentration under lean electrolyte conditions could potentially increase capacity retention, which may not align with the expected outcome. Secondly, the reviewer suggested that if the PI were to choose 20% FEC instead of 10% FEC in the baseline electrolyte under lean electrolyte conditions, the claimed 20% improvement in delivered capacity might not be observed, potentially resulting in an unsuccessful project outcome by December 2022.

Reviewer 2:

The reviewer commended the project for being well thought out and defined. However, there was a question about the potential cost increase when each component contains fluorine, as fluorinated materials are typically more expensive.

Reviewer 3:

The reviewer praised the general approach as excellent but suggested that an explicit description of the investigative structure of the study could have been improved for greater clarity.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer suggested that the modest improvement in capacity retention after 100 cycles in the LHCE versus the baseline electrolyte might be observed because of the deliberate choice of an electrolyte with 10% of FEC, as opposed to an increase to 20% FEC, which would consume FEC and potentially degrade faster. The reviewer recommended reporting realized energy densities of electrolytes, electrolyte loading, gassing behavior, and impedance rise to provide evidence of performance improvement compared to baselines, which should include a higher fraction of FEC.

Reviewer 2:

The reviewer acknowledged that the project had met all its milestones. However, there was a question about why it was crucial to quantify parasitic heat generation at this stage of development. Regarding the presentation of the “Best Gen 2 cell,” on Slide 9, the reviewer noted that it showed only about 60 cells retaining 80% capacity, suggesting that significant improvements were needed for cycle life performance. The reviewer inquired if there were any concerns about handling FLHCE (fluorinated lean high-capacity electrolyte) in terms of storage, moisture sensitivity, or other factors.

Reviewer 3:

The reviewer commended the bulk and analytical accomplishments, finding them well-executed and clear.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer commented that the collaborators had made meaningful contributions by providing valuable characterization data to aid in the understanding of capacity fade, indicating a fruitful collaboration.

Reviewer 2:

The reviewer stated that the collaboration with BNL and the National Institute of Standards and Technology (NIST) was described as very appropriate, highlighting the significance of these collaborations for the project.

Reviewer 3:

The reviewer commended the project for being well-described and demonstrated, suggesting that the project’s objectives and achievements were effectively communicated and substantiated.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer expressed uncertainty about how the proposed remaining work for the project, which includes characterizing the chemical composition of derived interfaces using hard X-ray photoelectron spectroscopy (HAXPES) and quantifying parasitic heat using isothermal microcalorimetry, would aid in improving performance. The reviewer suggested adding benchmark electrolytes with a high fraction of FEC to the proposed characterization of the electrochemical behavior of the localized high concentration electrolyte against a control electrolyte in 0.2 Ah cells to establish improved baselines. The reviewer also requested comments on the environmental effects of the proposed semifluorinated electrolytes.

Reviewer 2:

In terms of proposed future work, the reviewer noted that it was well-defined. There was a question regarding the 500 cycles goal, whether it aimed to achieve 80% capacity retention or 50% capacity retention, with the hope that it was the former. Additionally, the reviewer recommended studying cell thickness and pressure increase during cycling and at the end of cycling for 0.2 Ah multi-layer pouch cells.

Reviewer 3:

The reviewer concluded by stating that the proposed future work was well-aligned with the work done to date and appreciated that it incorporated feedback from previous reviewers. However, there was a suggestion to conduct additional calendar life testing, which would be beneficial.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer stated that the project objectives were aligned with and supportive of VTO goals.

Reviewer 2:

The reviewer noted that the project was related to the VTO Batteries subprogram within the context of the overall VTO objectives.

Reviewer 3:

The reviewer commented that this area of study was well-regarded by both industry and academia as a pathway to improve the life of high-Si content anodes, emphasizing its significance within the field.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that resources appeared to be sufficient for the results that were shown, indicating that the allocation of resources was appropriate for the achieved outcomes.

Reviewer 2:

The reviewer affirmed that the resources seemed to be sufficient to complete the stated goals of the project, suggesting that there were no immediate concerns regarding resource availability.

Reviewer 3:

The reviewer noted that while resources were sufficient, there might be a slight time constraint, given the project’s learnings. This indicated that the timeline may need careful management to ensure that the project stays on track.

Presentation Number: BAT534
Presentation Title: Devising mechanically compliant and chemically stable synthetic solid-electrolyte interphases on silicon
Principal Investigator: Pierre Yao (University of Delaware)

Presenter

Pierre Yao, University of Delaware

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

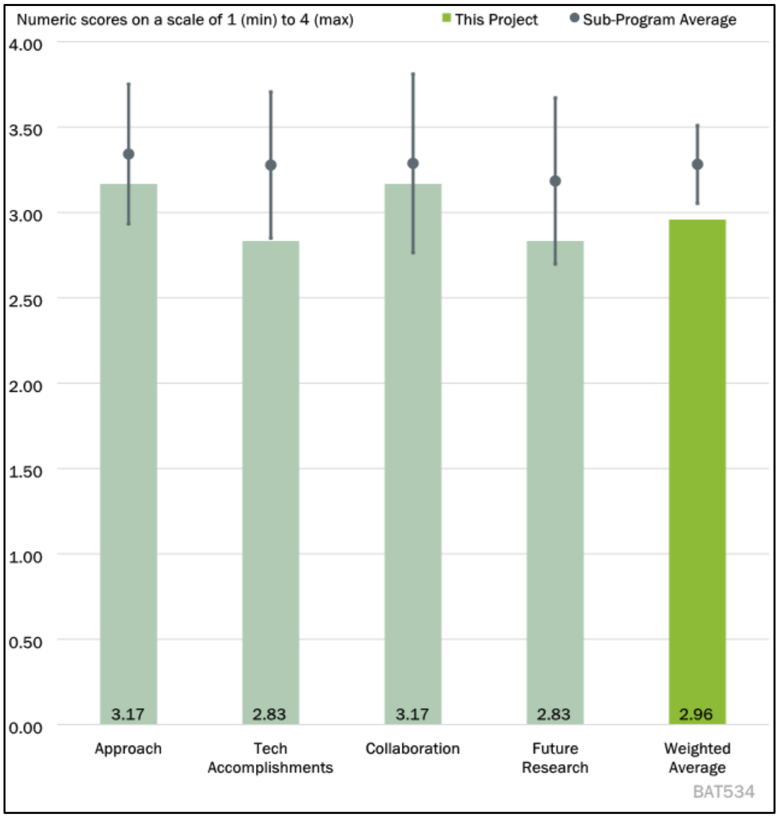

Figure 1-30 - Presentation Number: BAT534 Presentation Title: Devising mechanically compliant and chemically stable synthetic solid-electrolyte interphases on silicon Principal Investigator: Pierre Yao (University of Delaware)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer noted that while the project had demonstrated a significant improvement in the isoprene EP-coated Si in the FEC-free electrolyte, the performance was still poor. The reviewer suggested that it would be more informative to compare the performance of the new approach in state-of-the-art electrolytes rather than choosing a very poor baseline for comparison. This would provide a clearer understanding of the benefits of using the proposed approach in different electrolyte formulations.

Reviewer 2:

The project was described as well-defined in its exploration of new methods to stabilize the SEI layer, with the hope of improving the cycle and calendar life of a 100% Si-based anode. However, the reviewer considered the goal of achieving 1000 cycles to be very ambitious.

Reviewer 3:

The reviewer acknowledged the presence of a solid hypothesis and a plan to address that hypothesis. However, the reviewer pointed out a potential weakness in addressing other factors that may play as significant a role as the factors within the hypothesis, which could limit the degree of success achievable.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer noted that while the project had demonstrated performance improvement for high (80%) loading of Si through electropolymerization, the performance was still far below what was needed to achieve a successful year 2 go/no-go decision.

Reviewer 2:

The reviewer mentioned that all the milestones were completed on time, including a successful Go decision. However, the reviewer suggested that the proposed new methods, such as electropolymerization (EP) and electrophoretic deposition, were claimed to be low cost and low capital-intensive. The reviewer recommended showing some cost analysis to support these proposals. The reviewer inquired whether the authors understood why rapid capacity fade was occurring during the first approximately 10 cycles, as this issue needed to be addressed. The cycle life was considered very limited compared to the target, and it was suggested that significant improvements were required.

Reviewer 3:

In terms of future work, the reviewer acknowledged that the results had been good and that the proposed future work aligned well with the work done to date. However, the reviewer encouraged additional post-cycling cell characterization to better connect the effects of failure modes to the SEI modifications under test.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer commented that surface characterization, impedance, and FTIR (Fourier transform infrared spectroscopy) data had provided additional information but emphasized the need to present gassing and full cell data to provide a more comprehensive view of the project's progress.

Reviewer 2:

The reviewer noted that the facilities and expertise at ANL appeared to be utilized in the most effective manner, indicating the successful collaboration with ANL.

Reviewer 3:

The project was praised for its excellent description of team collaboration. However, the reviewer suggested that footnoting collaborators' contributions in the images would be helpful to provide clarity and credit to the collaborators for their specific contributions.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer expressed uncertainty about how long-term stability studies would contribute to material design if the capacity fade had already exceeded 20% after 30 cycles. Additionally, the very low CE of 76% on the first cycle suggested that a change in approach might be needed before conducting extensive long-term cycling and calendar life studies. The reviewer questioned the rationale for performing these studies if the performance deteriorated significantly after only a few cycles.

Reviewer 2:

The reviewer noted that the future plan was well-defined and potentially aligned with the project's targets.

Reviewer 3:

The reviewer emphasized that any improvement in achieving the targets would be dependent upon the analyses and feedback generated during the course of the work. The reviewer also highlighted that the gap to reach 1000 cycles appeared to be very large, and it was unclear how likely it was to be achieved based on the current performance.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer agreed that the project is relevant.

Reviewer 2:

The reviewer stated that this project was related to the VTO Batteries subprogram of the overall VTO objectives, aligning it with the broader goals of VTO.

Reviewer 3:

The reviewer noted that the hypothesis being pursued in the project was well-accepted by both academia and industry. This indicated that the work being undertaken in the project was consistent with ongoing efforts in both academic and industrial research.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer observed that significant resources had been allocated to the project, indicating a substantial commitment to its success.

Reviewer 2:

The reviewer affirmed that the resources appeared to be sufficient and appropriate to meet the stated goals of the project, suggesting that there were no immediate concerns regarding resource adequacy.

Reviewer 3:

The reviewer noted that there was no indication in the project’s work that resources were insufficient, and that milestones were being achieved at a pace like the original project proposal, reflecting a well-managed allocation of resources.

Presentation Number: BAT544
Presentation Title: Machine Learning for Accelerated Life Prediction and Cell Design
Principal Investigator: Eric Dufek (Idaho National Laboratory)

Presenter

Eric Dufek, Idaho National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 25% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

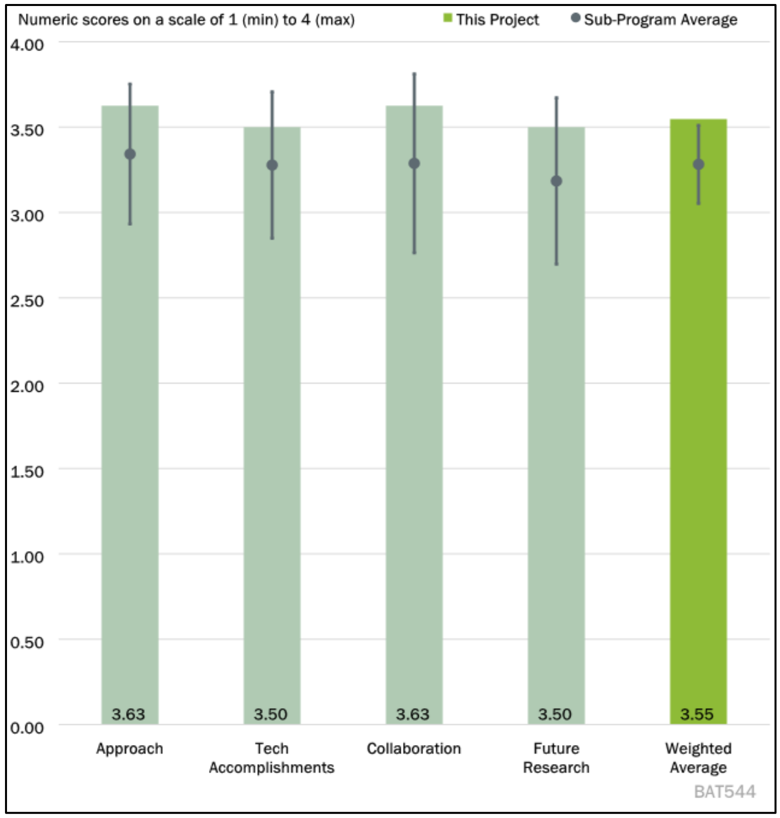

Figure 1-31 - Presentation Number: BAT544 Presentation Title: Machine Learning for Accelerated Life Prediction and Cell Design Principal Investigator: Eric Dufek (Idaho National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer praised the project for establishing a thorough approach to coupling existing data, database management, and a public platform. The development of milestones was acknowledged as providing a clear path toward achieving project objectives.

Reviewer 2:

The reviewer noted that many of the predictions in the project depended on synthetic data that had been generated. It was emphasized that the quality of predictions relied on the quality of the synthetic data generated. The reviewer also pointed out that validation over 600 cycles had been minimal due to a lack of data availability and suggested that analysis with fast charging rates would have been more helpful.

Reviewer 3:

The reviewer commended the width and depth of the project, saying it was well thought out. Predicting battery life and understanding failure modes were deemed crucial for the rapid development of battery technology.

Reviewer 4:

The reviewer highlighted several key aspects of the project, including the use of a battery physics-based P2D (pseudo-2D) model to generate synthetic data, the exploration of physics-informed neural networks to improve model quality, the utilization of deep learning algorithms to identify battery failure modes, and the comparison and evaluation of different performance and failure mode prediction frameworks in a systematic manner.

Additionally, electrochemical signatures were used to identify and classify aging modes, and a decision tree algorithm was employed to enhance classification quality.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer observed that the accuracy and usability of the physics-informed cross-barrier charging method were clearly demonstrated, reducing the need for inefficient rate performance test (RPT) - low C rate battery health assessments and leading toward the ability for real-time monitoring. The reviewer stated that the project demonstrated the feasibility of a physics-informed neural network approach, supporting a primary objective. The reviewer also remarked that the project demonstrated predictiveness as well as descriptiveness (i.e., establishing aging modes), further supporting a primary objective.

Reviewer 2:

During the evaluation, the reviewer commented that one of the points raised was the prediction of catastrophic failure, while another reviewer expressed the view that the model was not particularly useful for detecting abnormalities from a single cell. In essence, the model was observed to predict only “average” degradation. These points were deemed in need of addressing.

Reviewer 3:

The reviewer questioned why tasks that were due by June 2, 2022, were still in progress status—a delay of almost one year. Similarly, the other two tasks were delayed by almost 9 months.

Reviewer 4:

The reviewer affirmed that the project had accomplished most of the proposed objectives in the current fiscal year.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer remarked that the project has clearly developed and fostered an extensive collaboration and cooperative approach to access, collect, manage, and evaluate data and simulations.

Reviewer 2:

The reviewer stated that while this is primarily a national laboratory oriented project, it is worth noting that incorporating real-world data from vehicle OEMs would be valuable. This becomes especially critical considering the newly proposed U.S. Environmental Protection Agency (EPA) standards for battery health monitoring algorithms beyond Model Year 2027. The reviewer stated confidence that several vehicle OEMs are likely pursuing similar approaches for future compliance, and establishing collaborations with the industry could provide a common framework.

Reviewer 3:

The reviewer praised the initiative of the PIs in reaching out to behind-the-meter-storage for elaborate collaboration, in addition to other projects.

Reviewer 4:

The reviewer pointed out that the project, led by INL, involves collaboration among several national laboratories. It was verified that stakeholder interviews have been conducted to collect industry opinions. The reviewer clarified that the project may further benefit from university collaboration, especially in the realm of battery physics knowledge. While the P2D model is a good starting point, it was observed that some assumptions of the model have been proven incorrect. The reviewer articulated that incorporating new and key physical insights into battery physics and failure mechanisms may significantly enhance the model's quality.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer stated that the project identifies and plans to address the large variability in data quality.

Reviewer 2:

The reviewer noted that the project is 80% complete, and there is not much left to comment on for future work.

Reviewer 3:

The reviewer found the proposed future work to be well defined. The reviewer strongly suggested conducting modeling work for the cells that use practical loading of at least 3.5 mAh/cm^2 and quickly transitioning to preferred loading of 4.0–4.5 mAh/cm^2.

Reviewer 4:

The reviewer found the proposed future research to be comprehensive. It was suggested that the failure mode analysis may benefit from new knowledge in battery physics and failure mechanisms, especially under demanding conditions such as high charging rates, low temperatures, and so on.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer affirmed that this work aligns closely with the VTO objectives.

Reviewer 2:

The reviewer pointed out that battery state of health monitoring algorithms will be needed beyond Model Year 2027. They emphasized that these types of work conducted at national laboratories are critical and support the mission of the agency.

Reviewer 3:

The reviewer observed that the project is highly relevant to Batteries subprogram of VTO.

Reviewer 4:

The reviewer commented that the project is a great asset to the VTO program, as it provides a unique and important angle to examine, understand, and optimize batteries at both the cell and system levels. They highlighted that it complements material research efforts. The developed model, tools, practices, and methods for combining data with a physical understanding can be generalized to different battery chemistries, batteries of various scales and sizes, thereby enabling improved battery usage for enhanced safety and lifespan.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer asserted that the project's funding and effort are sufficient to successfully accomplish its objectives, which primarily involve evaluating battery performance, specifically lifetime and health.

Reviewer 2:

The reviewer noted that the project has been nearly completed.

Reviewer 3:

The reviewer commented that the team is very well equipped in terms of resources.

Reviewer 4:

The reviewer stated the work has a very wide scope, bringing together experts with different backgrounds, including computation specialists, experimentalists, chemists, physicists, battery engineers, and data scientists. The reviewer emphasized the importance of such a multi-disciplinary team to the success of this project, as it requires the integration of a deep physical understanding of battery operation, chemical insights into battery failure, electrochemical modeling of batteries, battery testing, ML modeling, and the establishment of data infrastructure to achieve the project's goals. The reviewer also pointed out that this project differs significantly from a "typical" VTO project. Given the project's scope, the reviewer suggested that the team may benefit from an increased budget to ensure that all the key expertise required for the project's success can be included and any potential weaknesses can be addressed.

Presentation Number: BAT546
Presentation Title: Scaling-Up and Roll-to-Roll Processing of Highly Conductive Sulfide Solid-State Electrolytes
Principal Investigator: Dongping Lu (Pacific Northwest National Laboratory)

Presenter

Dongping Lu, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 60% of reviewers felt that the resources were sufficient, 20% of reviewers felt that the resources were insufficient,20% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

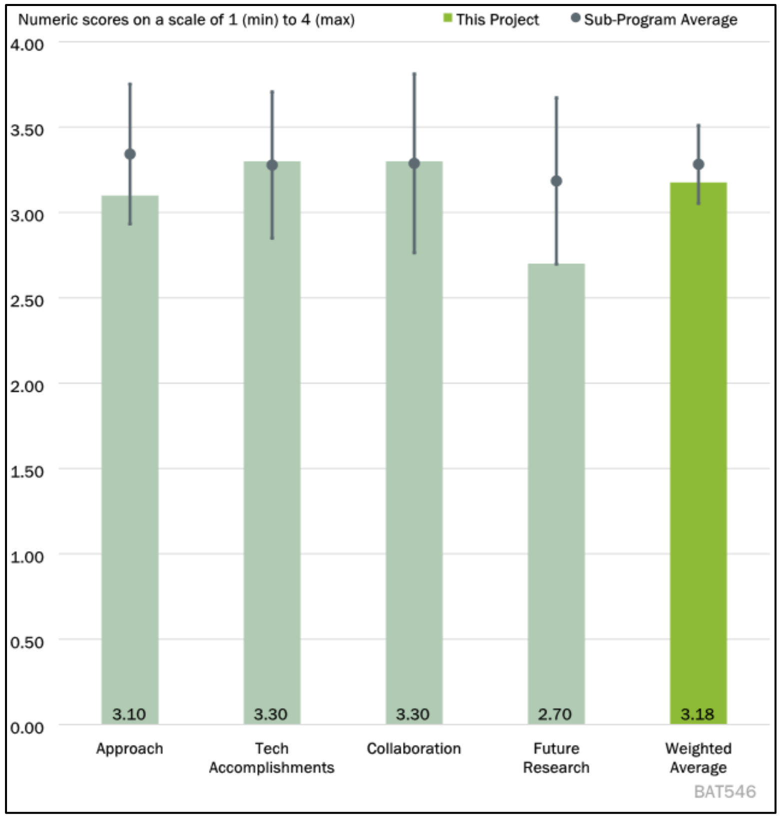

Figure 1-32 - Presentation Number: BAT546 Presentation Title: Scaling-Up and Roll-to-Roll Processing of Highly Conductive Sulfide Solid-State Electrolytes Principal Investigator: Dongping Lu (Pacific Northwest National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer appreciated the overall approach but noted that relying solely on conductivity as a screening parameter may be insufficient, as most sulfur-based electrolytes are not stable at high or low voltages.

Reviewer 2:

The reviewer noted the approach primarily focuses on the synthesis of sulfide SSEs using liquid-phase processing methods. The reviewer found the work to be well-presented and relevant. However, they raised concerns about the project’s limited scope in terms of evaluating materials and components in a cell environment under relevant pressure and temperature conditions. The reviewer stressed the importance of including testing in a device at pressures below 1 MPa and at temperatures relevant to link synthesis changes with their impact on device processing.

Reviewer 3:

The reviewer pointed out that the project mainly addresses lower technology readiness level (TRL) development and does not emphasize scalability and handleability at the higher levels required for larger batch synthesis for cell scale-up. They also noted the importance of the project’s focus on lower-temperature synthesis rather than ultra-high temperatures.

Reviewer 4:

The reviewer stated the project's goal is to develop a process for making a separator of a solid electrolyte based on a halide-doped sulfide. The reviewer highlighted the use of a robot to assist in the screening process and suggested that selecting an appropriate solvent and binder could enable the creation of slurries, film casting, and performance measurement.

Reviewer 5:

The reviewer observed that the team is utilizing a high-throughput screening method to identify optimized solvents and binders for processing sulfide SSEs. They proposed the creation of a database or library to determine the solubility and other physical properties of solvents and binders, which would be critical for scaling SSBs. Additionally, the reviewer praised the emphasis on dry processing of solid electrolyte membranes, which can save costs and avoid the use of organic toxic solvents.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer acknowledged good progress in the project but expressed concerns regarding certain parameters that may limit its applicability for automotive applications. Specifically, the requirement for 500 MPa pressure, equivalent to about 5000 atmospheres, was deemed impractical for automotive use. Additionally, a thickness of 41 microns and a conductivity under 1 mS/cm raised concerns about the material's suitability for room temperature performance, as the resistance could potentially be too high.

Reviewer 2:

The reviewer commended the technical progress made within the project, especially considering the $500,000 annual budget. They noted that the project had explored synthesis, measured IC, and conducted work on component fabrication, such as separators.

Reviewer 3:

The reviewer emphasized the need for further work in balancing electrochemical properties with mechanical properties to achieve the highest performance while maintaining low interfacial resistance and high flexibility. Moisture absorption by the SSE was highlighted as a significant issue for scale-up and handleability. The reviewer suggested that addressing this challenge might require more than proper sealing and potentially involve reworking the materials within the SSE. While initial data on cell performance with the SSE appeared promising, the reviewer raised concerns about rate capability and cycle life, particularly considering the current stage of the project. The reviewer also noted that the project seemed to be lagging other efforts with later start dates.

Reviewer 4:

The reviewer provided specific insights into the project's achievements, including the development of a database of compatible solvents for SSEs, the correlation between solvent polarity and solubility, and the importance of sealing during scale-up. They highlighted the successful development of a binder and solvent, as well as process conditions suitable for industrial scale-up. The collaboration with Ampcera to develop a complete NMC/SSE/Li cell was also noted as an accomplishment.

Reviewer 5:

The reviewer recognized several excellent accomplishments, such as the database of compatible solvents and the successful scaling up of $Li_7P_2S_8Br_{0.5}I_{0.5}$ solid electrolyte. However, they also raised valid concerns about the project's feasibility for automotive applications and the need for further improvements in cell performance.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer observed collaboration across the team seems to be working well but was not discussed in detail.

Reviewer 2:

Regarding Ampcera's role, the reviewer noted there was uncertainty about how their contributions complemented the work of PNNL. It was unclear to the reviewer what Ampcera was doing for this project that was not already part of their current work. Additional information on the specific role and contributions of Ampcera to the project would provide clarity. The reviewer also mentioned Thermo Fisher's involvement in electrode characterization, but no further details were provided about their role within the project.

Reviewer 3:

The reviewer noted there was good collaboration.

Reviewer 4:

The reviewer commended the small team of partners for their successful collaboration, particularly in achieving scale-up and the fabrication of a full cell.

Reviewer 5:

The reviewer highlighted the excellent teamwork among partners, which included national laboratories, industry, and a research university. The achievement of scale-up up to 250 g of solid electrolyte powders using industrial milling process was noted as an example.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer expressed concerns about the project's focus on scale-up, suggesting that the current batches' performance and parameters were not yet suitable for automotive cells. They emphasized that the project should prioritize improving the performance of current batches to meet the required standards.

Reviewer 2:

The reviewer noted the future work plan was to be primarily centered on synthesis and IC measurements. The reviewer reiterated the importance of establishing a strong connection between the synthesis efforts and the evaluation of components and devices for the project to have a high impact. For instance, creating an ultra-thin separator is valuable, but its effectiveness in a device context should be a key consideration.

Reviewer 3:

The reviewer acknowledged that future plans address significant barriers to implementing SSE on a large scale. However, they pointed out that the mechanical integrity of the SSE regarding preventing Li dendrite growth had not been discussed. Evaluating whether the SSE has this property would be a useful assessment.

Reviewer 4:

The reviewer stated the project's desire to achieve a more uniform particle size and find a suitable binder for making thin separators. The reviewer noted that it was unclear whether the project had a list of binders to try or specific methods to address the particle size issue.

Reviewer 5:

The reviewer highlighted the team's goal to develop approaches to reduce particle size while maintaining high IC for sulfide SSE. Additionally, they mentioned the intention to use the solvent and binder information developed thus far to fabricate ultra-thin solid separators and cathode films at relevant scales.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer noted that the project is very relevant.

Reviewer 2:

The reviewer commented that the project is highly aligned with the goals of the Batteries program. SSEs were recognized as being of high relevance to the program's objectives.

Reviewer 3:

The reviewer saw the project as a valuable contribution to the Advanced Materials R&D efforts and to be closely aligned with the goals of the VTO.

Reviewer 4:

The reviewer acknowledged that while sulfides have good conductivity, their stability poses a significant challenge. The project was commended for addressing this challenge by working on ways to create electrolytes and composite electrodes using sulfides.

Reviewer 5:

The reviewer emphasized that the processing and scaling of SEs, as pursued in the project, would play a crucial role in accelerating the development of SSBs that align with VTO's battery R&D performance targets, which include achieving 500 Wh/kg and 1000 deep discharge cycles.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer found the project's funding level to be somewhat high, particularly considering the active efforts of the industry in addressing similar challenges.

Reviewer 2:

The reviewer expressed concerns about the project's ability, with an annual funding of $500,000 from the DOE, to establish a strong connection between synthesis and processing work and the evaluation of these materials in a device setting, especially regarding relevant applied pressures and temperatures. The reviewer recommended enhancing the alignment of the project with cell building efforts to maximize its impact.

Reviewer 3:

In terms of resources for achieving full project success, the reviewer deemed them reasonable based on the project's approach and progress.

Reviewer 4:

The reviewer stated that from the research team's approach and progress, the team seems to have reasonable funding.

Reviewer 5:

The reviewer noted that the project's funding level appeared to be appropriate for its objectives and milestones, supporting optimal execution.

Presentation Number: BAT547
Presentation Title: Continuous high yield production of defect-free, ultrathin sulfide glass electrolytes for next generation solid state lithium metal batteries
Principal Investigator: Tim Fister (Argonne National Laboratory)

Presenter

Tim Fister, Argonne National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

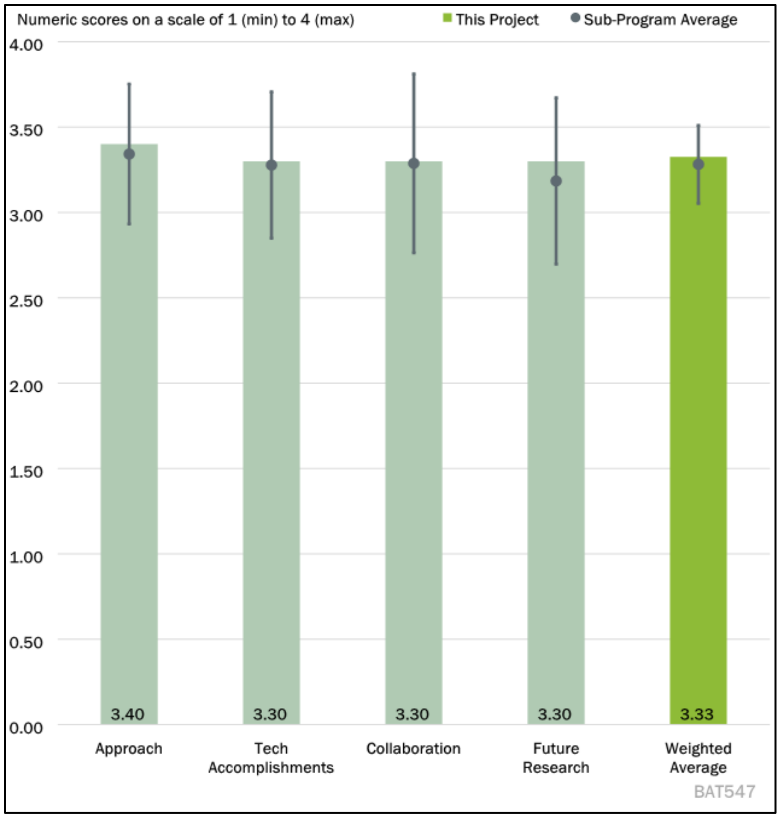

Figure 1-33 - Presentation Number: BAT547 Presentation Title: Continuous high yield production of defect-free, ultrathin sulfide glass electrolytes for next generation solid state lithium metal batteries Principal Investigator: Tim Fister (Argonne National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer expressed positive feedback on the project's approaches to improving thin sulfide SSEs and found no major issues with the project.

Reviewer 2:

The reviewer noted that the project was well-targeted at addressing a characterization need for a material and component from PolyPlus. The characterization work was seen as contributing to the development of glass at PolyPlus by identifying the composition and potential sources of impurities.

Reviewer 3:

The reviewer stated that the presentation effectively conveyed that sulfides can be made into glasses, and thin glasses exhibit flexibility and conductivity, making them suitable for roll-to-roll processing of batteries. The negative impact of impurities on conductivity was also clearly communicated. The project's approach involved using multiple diagnostic tests to identify the location and type of impurities formed in sulfide laminates during production, from powder to ingot to preform (thick slab) to thin film (final product).

Reviewer 4:

The reviewer appreciated the use of total X-ray scattering methods to characterize the local and bulk structure of sulfide glass electrolytes. They noted that even tiny amounts of crystalline or non-crystalline impurities can affect the formation of defect-free ultra-thin glass solid electrolytes. The combination of powder diffraction and PDF methods was recognized for determining impurity levels and concentrations. Surface/interfacial defects were characterized using various techniques, including SEM/energy-dispersive X-ray spectroscopy (EDS), glow discharge optical emission spectrometry (GDOES), and digital holographic microscopy (DHM).

Reviewer 5:

The reviewer was concerned about the large background in the PDF measurement due to the use of SiO_2 as the container. They suggested considering alternative containers, such as polyimide-based or single-crystal sapphire containers, which produce negligible backgrounds and may improve PDF data processing.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer expressed concerns about the thickness of the SSEs, which were stated to be between 100 and 1000 microns thick. They pointed out that for use in automotive cells, thinner SSEs of around 20 microns may be necessary. Additionally, the reviewer noted that defects, which were already an issue in relatively thick films, might become more prevalent in thinner ones. They raised questions about how to avoid defect formation, especially if post-processing thermal treatment is the cause.

Reviewer 2:

The reviewer praised the project's alignment with contributing to the PolyPlus workflow, and they found that specific contributions by the characterization work were evident. They noted that the project's goals appeared to have been achieved.

Reviewer 3:

The reviewer commented the presentation for presenting the results of PDF and powder XRD analysis, demonstrating the presence of few defects in the core and the ability to measure their location and concentration after pressing. The project's approach to ion-cleaning to remove defects formed during the preform step was noted. The reviewer outlined the project's hypothesis about the sources of defects and demonstrated that the material itself slightly crystallizes during the preform process, likely due to internal heating. A comparison between the boron-based glass of interest and a more popular phosphorus-based sulfide glass was provided, indicating that the phosphorus-based glass was less susceptible to internal crystallization during the preform step. The preliminary results of a Raman probe were also noted as promising.

Reviewer 4:

The reviewer highlighted specific objectives related to studying the origin of impurity formation during glass formation, monitoring the onset of crystalline phases, and analyzing extensive X-ray and PDF measurements on borate-based sulfide glass electrolytes at various stages of the glass formation process.

Reviewer 5:

The reviewer acknowledged that the PI had successfully identified and quantified the crystalline defects, particularly noting that impurities had similar local structures to the LiB_xS_y glass electrolyte but exhibited long-range order. This knowledge had contributed to optimizing the LiB_xS_y electrolyte synthesis process. Comparisons and mapping had also been conducted for both LiB_xS_y and LiP_xS_y electrolytes. Overall, the reviewer praised the project's research efforts and results.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer noted that the collaboration between the project team and PolyPlus appeared to be working well.

Reviewer 2:

The reviewer noted that ANL received samples from PolyPlus and provided specific feedback to them, which was deemed useful. This collaboration was recognized as a positive and functional example.

Reviewer 3:

Despite not having many partners on the team, the reviewer acknowledged the project as having a strong industrial partner, PolyPlus Battery Company, which was seen as having the potential to convert the research results into improved battery components. Additionally, the project's collaboration with researchers at the Advanced Light Source (ALS) was mentioned as a positive aspect of the teamwork.

Reviewer 4:

The reviewer expressed interest in knowing whether the samples used in the project were synthesized by the ANL team or supplied by PolyPlus.

Reviewer 5:

The reviewer said that the PI's collaboration with individuals within ANL and with industry partner PolyPlus Battery Company, known for its capability to produce very thin glass electrolytes, contributed to the project's success.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer commended the project's good focus on defect formation and its consideration of ways to minimize defects in future work.

Reviewer 2:

The reviewer stated that the future work proposed, particularly focusing on interfaces, was important and relevant. They expressed a particular interest in this aspect of the project.

Reviewer 3:

The reviewer remarked on the project's plan to modify its equipment to investigate batteries for the formation of impurities in both the bulk and on the surface. They also noted the project's intention to use materials produced by the industrial partner.

Reviewer 4:

The reviewer observed the team's plan to examine impurities at the Li/glass interface and the inclusion of imaging methods such as tomography and DHM to measure the topography of the glass and buried glass/Li interface.

Reviewer 5:

The reviewer questioned whether the project's plan to carry out *in situ* PXRD and tomography during battery cycling to gain a better understanding of defect development and crystalline impurities in the solid electrolyte at different battery life cycles was reasonable. The reviewer asked for clarification on the project's plan to study impurities at the Li-glass electrolyte interface and sought more information on how this aspect of the research would be conducted.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer affirmed that the project is highly relevant.

Reviewer 2:

The reviewer found the PolyPlus approach to be interesting and noted that the project is contributing to the development of that approach.

Reviewer 3:

The reviewer stated that the work aligns well with the efforts of VTO to better understand SSBs and their potential as a replacement for Li-ion batteries. They recognized that this project supports VTO's efforts in this regard.

Reviewer 4:

The development of thin, flexible glassy solid electrolytes was seen by the reviewer as having the potential to accelerate the development of all SSBs, and the project was noted to be aligned with VTO's battery R&D target of achieving 500 Wh/kg with 1000 deep cycles.

Reviewer 5:

Overall, the reviewer emphasized that this SSE project, focused on studying glass electrolytes, supports the broader objectives of VTO's Batteries subprogram.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer remarked that the project offers good value for its R&D investment.

Reviewer 2:

Despite having a small budget, the reviewer commented the project to be productive and effectively collaborating with industry partner PolyPlus, which was seen as a positive aspect.

Reviewer 3:

The reviewer observed that the researchers had made excellent progress, generated interesting results, and had a clear plan for moving forward.

Reviewer 4:

The project's funding level was considered adequate by the reviewer to support the project's collaboration with PolyPlus, reinforcing the notion of effective resource utilization.

Reviewer 5:

The reviewer affirmed that the project had sufficient resources to achieve its stated milestones in a timely manner.

Presentation Number: BAT548
Presentation Title: Scale-Up of Novel Li-Conducting Halide Solid State Battery Electrolyte
Principal Investigator: Mike Tucker (Lawrence Berkeley National Laboratory)

Presenter

Mike Tucker, Lawrence Berkeley National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 80% of reviewers felt that the resources were sufficient, 20% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

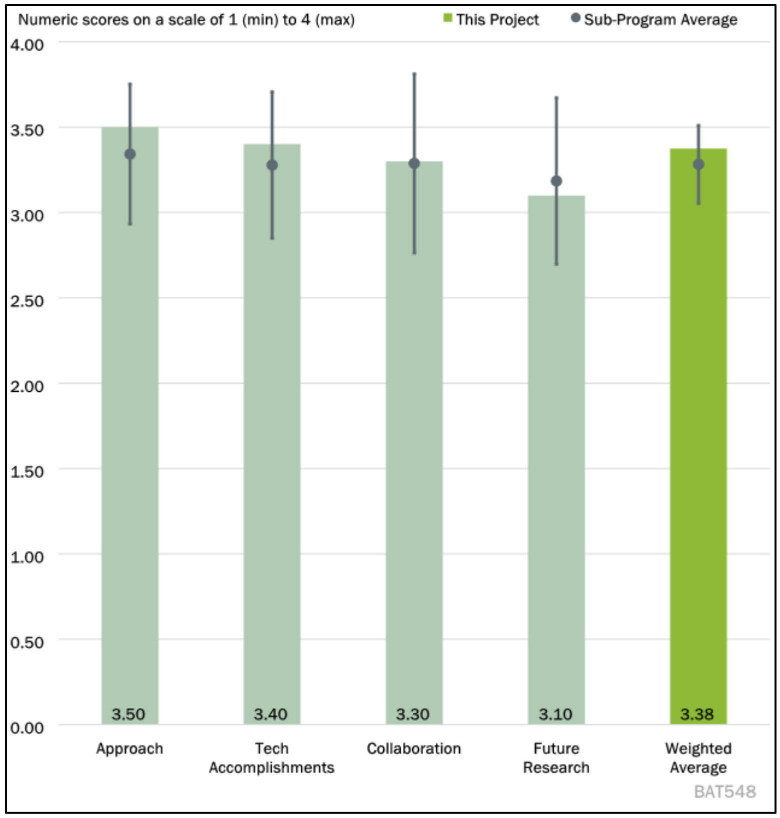

Figure 1-34 - Presentation Number: BAT548 Presentation Title: Scale-Up of Novel Li-Conducting Halide Solid State Battery Electrolyte Principal Investigator: Mike Tucker (Lawrence Berkeley National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer affirmed that the approach taken in the project was appropriate and aligned with the goal of developing a halide SSE in collaboration with Saint-Gobain.

Reviewer 2:

The reviewer noted that the project's approach made sense, which involved obtaining a powder from a commercial supplier and attempting to make a device with it while addressing challenges in component processing and device construction. The chosen powder was considered a reasonable candidate compared to other materials under investigation, and the approach leveraged the significant expertise of the PI and LBNL to seek progress.

Reviewer 3:

The reviewer suggested that the PI further investigate the substrate for the coating process, particularly how easy or difficult it is to remove the SSE coating. Additionally, they recommended investigating the threshold moisture level for casting.

Reviewer 4:

The reviewer stated the project's approach addresses key barriers to implementing a full halide battery, including barriers at each component level. The transition from coin cells to pouch cells was seen as a significant step, as it would help identify and address scale-up issues early in the effort.

Reviewer 5:

The reviewer recognized the project team's goal is to develop a scalable processing and fabrication method for designing SSBs using halide-based SEs. The reviewer mentioned that the demonstrated approach included using tape casting to fabricate thin halide-based membranes and integrating them with a thick NMC and thin Li anodes. The use of Li-In as the anode material for solid-state cathode testing was mentioned as an intermediate step. Year-I goals included selecting the appropriate binder and solvent for tape casting halide solid electrolytes supplied by the industrial partner, Saint-Gobain, and using Li_3N as an interfacial coating to stabilize the halide solid electrolyte with Li-metal.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer expressed concerns about the project performance, stating that it was quite poor and faced significant challenges. They noted that instability at both the NMC cathode and the Li anode posed major challenges. The reviewer expressed skepticism about the likelihood of success for this class of material and pointed out relatively poor conductivity, as evidenced by the significant drop in capacity at 0.2C compared to 0.02C, which was almost 50%. They also mentioned that the low-rate capacity was quite low and suggested a need to investigate this further. However, the reviewer acknowledged that LBNL's work was of high quality.

Reviewer 2:

The approach taken by the project was considered reasonable, but the reviewer noted that it was clear that the project faced significant challenges, including those commonly associated with SSBs. One of the known challenges was the requirement for high pressures (tens of MPa), which had proven difficult to overcome elsewhere. A unique challenge identified by the team was the inability to use binder burnout due to the 300°C stability window of the solid electrolyte. This was expected to make cycling the cell more challenging and limit performance due to the presence of remaining binder, which could reduce IC. The reviewer recognized the PI's awareness of these challenges and their focus on addressing them, with additional technical progress expected.

Reviewer 3:

The reviewer acknowledged great progress in several areas, including the screening of solvents and binders for compatibility with the halide SSE, determination of binder burnout temperature, conductivity assessment, and cell performance testing. They also mentioned their expectation to learn about the compatibility of Li metal with the halide in the following year.

Reviewer 4:

The reviewer noted the approach's flexibility in terms of which cathode the system is paired with and its assessment of different chemistries to demonstrate this. However, the reviewer pointed out the high risks associated with the required stack pressure and its potential impact on the final watt-hour per kilogram. There was also concern about limitations based on the instability of the electrolyte at higher potentials, which the project was addressing through new materials studies.

Reviewer 5:

The reviewer recognized several technical accomplishments by the team, including screening the binder and solvent system, achieving a critical current density (CCD) of 1.5 mA/cm^2 using Li-In electrodes, and conducting SSB testing using halide solid electrolyte and tape-casted NMC and LFP electrodes. However, they emphasized the need for further investigation into the poor capacity retention and optimization of the Li_3N interfacial coating approach compared to the Li-In anode.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer recognized the value of the project's collaboration with industry on SSEs.

Reviewer 2:

The reviewer noted that the collaboration appeared to be functioning well, with Saint-Gobain providing the solid electrolyte and cost sharing while LBNL focused on making a cell.

Reviewer 3:

The reviewer emphasized the critical nature of the PI's collaboration with Saint-Gobain, given the company's expertise in producing halide chemicals. They suggested that the PI consider extending the collaboration to other SSE producers.

Reviewer 4:

The partnerships within the project were seen by the reviewer as going well, and the work was noted to be coordinated effectively across the various groups involved.

Reviewer 5:

The reviewer mentioned the involvement of the ALS and SLAC to support degradation studies of SSB cells. They suggested the need for a detailed plan to be laid out in this regard. Additionally, they noted that the industry partner had scaled the halide solid electrolyte synthesis to the kilogram level and was currently optimizing new compositions.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer expressed concerns about the readiness of the material for scale-up and suggested caution in pursuing it. They noted that the cathode should not be cracking and recommended collaborating with other national laboratories or industry partners to improve electrode processing. The reviewer also highlighted the importance of reducing pressure, as maintaining 500 atmospheres of pressure in an automotive battery was considered challenging.

Reviewer 2:

The reviewer remarked that the proposed work was reasonable, with a focus on creating a high-energy cell that would require the use of Li metal and an anode protection layer. They acknowledged that the team would encounter and identify challenges while working with this material.

Reviewer 3:

In the short term, the reviewer advised the PI to focus on assessing the compatibility of metallic Li anode with the halide SSE.

Reviewer 4:

The reviewer articulated that the shift towards pouch cell demonstrations was seen as a positive move, as it would help uncover scale-up issues early in the project's development.

Reviewer 5:

The reviewer noted that the future work plan addressed barriers for each component and outlined plans for moving forward. They recognized the team's clearly defined goals and metrics for future research, including the continued optimization of solid-state cathodes and anode interlayer coatings, scaling the tape casting capability, assessing the impact of stack pressure on cell performance, and minimizing interfacial resistance between tape-casted cathode sheets.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer affirmed the relevance of the SSE R&D in the project, considering the solid electrolyte as a reasonable candidate.

Reviewer 2:

The reviewer noted that working on making a cell with it was a good approach to identify issues and address Battery program goals.

Reviewer 3:

The reviewer articulated that the project's relevance rested on the development of a processing technology to enable the continuous production of SSBs.

Reviewer 4:

The reviewer expressed that this effort was very well aligned with the Advanced Materials R&D work funded by VTO.

Reviewer 5:

The reviewer observed that the processing and scaling of halide-based solid-electrolyte would enable the development of all SSBs, and they emphasized the strong alignment of the project with VTO's battery R&D performance target of 500 Wh/kg with 1000 deep cycles.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that the resources allocated to the project were reasonable.

Reviewer 2:

The reviewer pointed out that achieving a 300 Wh/kg cell with good performance is an extremely challenging task. They noted that startups working on such projects typically have larger teams. The reviewer suggested that the project is more likely to identify issues to address rather than to create a compelling 300 Wh/kg cell, especially considering challenges like high stack pressure. Nevertheless, they recognized that identifying unique issues with this material could still be valuable to the DOE and the Saint-Gobain Corporation.

Reviewer 3:

The reviewer affirmed that the PI had adequate resources to conduct the proposed research.

Reviewer 4:

The reviewer expressed that the resources were sufficient to fully execute the project.

Reviewer 5:

The reviewer concluded that the project was funded at the appropriate level to deliver towards the milestones.

Presentation Number: BAT571
Presentation Title: ReCell Center-Direct Recycling of Materials
Principal Investigator: Jessica Durham Macholz (Argonne National Laboratory)

Presenter

Jessica Durham Macholz, Argonne National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 25% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

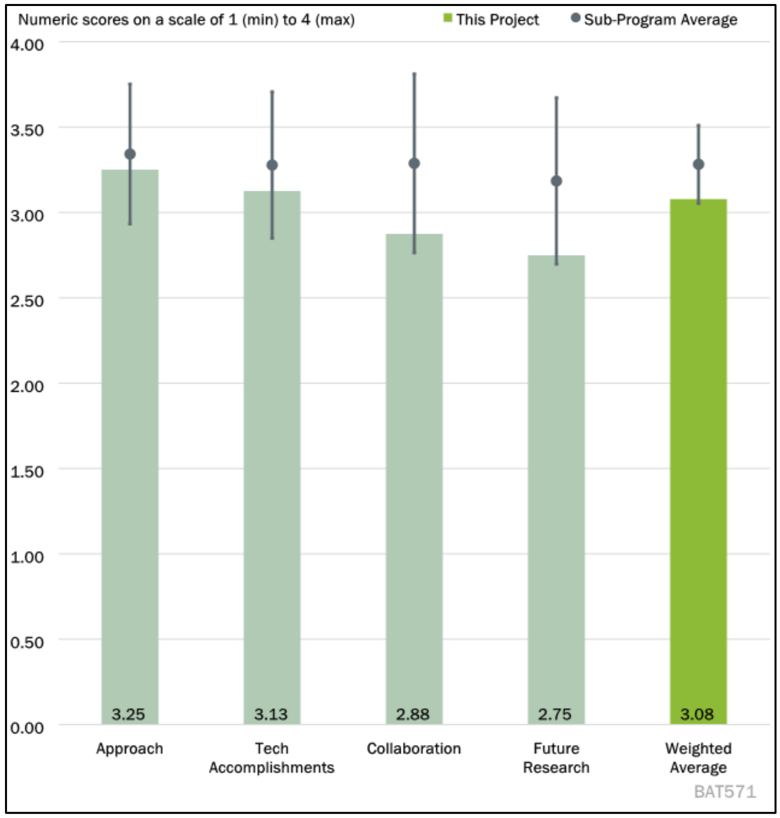

Figure 1-35 - Presentation Number: BAT571 Presentation Title: ReCell Center-Direct Recycling of Materials Principal Investigator: Jessica Durham Macholz (Argonne National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer stated that the approach from used cell/material to recycled product was clear, and many of the challenges raised by reviewers were already being addressed. However, they expressed a concern that the methods appeared to be primarily focused on being cost-competitive for transition metal oxides, and they suggested that direct recycling methods could be useful for polyanion cathodes or anode materials if a way to justify the economics could be found.

Reviewer 2:

In reviewing the overall projects in this area, the reviewer commented that the projects were well designed, and the timeline appeared to be reasonably planned.

Reviewer 3:

The reviewer acknowledged that the technical barriers were identified, and the corresponding timeline seemed reasonable. However, they raised a question about whether a technical solution, once found, would be practical and adoptable by industry at scale. They suggested re-evaluating the distribution of the 26 projects across sub-topics, as they felt that the 20 projects assigned to cathode and anode separation and relithiation/upcycling might be excessive. They also expressed uncertainty about the likely application areas for cathode separation and upcycling.

Reviewer 4:

The reviewer pointed out that the project did not clearly identify the technical barriers specific to direct recycling of materials, beyond cost. They noted that there were many other potential barriers. They also mentioned that the presentation lacked information about which partners in the consortium were involved in each of the 26 projects, and they suggested it would have been appropriate to indicate partner involvement for clarity.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer remarked that the projects had shown good progress, with many efforts achieving over 95% recovery, purity, or yield. They noted that there were numerous proof-of-concept demonstrations that showed the feasibility of the direct recycling concept. However, the reviewer pointed out that the challenge going forward would be to improve towards battery-grade materials.

Reviewer 2:

In evaluating the projects, the reviewer commented that they seemed to be at various stages of technical progress, but all were progressing according to the project plan.

Reviewer 3:

The reviewer acknowledged that progress had been made in most of the projects and anticipated additional progress as research activities continued. However, they emphasized the critical importance of adhering to rigorous specifications for battery-grade qualifications and ensuring that the end objective of achieving parity with virgin materials was achievable. They suggested that achieving a maximum purity of 99% might not be sufficient for large-scale use by the battery industry, which could require even higher purity levels.

Reviewer 4:

The reviewer noted that more than 20 technical approaches were investigated, and it was challenging to discern which activities were part of the project plan. They suggested that the researchers should quickly down-select the more promising approaches and focus on those rather than pursuing every possible approach.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer observed that there were numerous people involved in the effort, and it was a bit challenging to discern how much work was standalone by different groups and how much involved collaboration.

Reviewer 2:

The reviewer commented that collaboration with laboratories and other entities appeared to be adequate.

Reviewer 3:

The reviewer praised the collaboration between project teams and national laboratories, describing it as very good. They also encouraged further collaboration with partners who would be the end-users of the materials, as well as recyclers who would use the recycling processes developed. They noted that these entities would provide valuable insights into practical challenges beyond technical ones.

Reviewer 4:

The reviewer stated that there seemed to be good collaboration but mentioned that it was not clear which partner was responsible for each project. They also highlighted that it was unclear if industry partners were involved in each of the activities.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer intimated that moving the efforts into kg scale/pilot scale trials is a logical next step for the technology development. However, the purpose of the scale-up and how the ReCell center will use the effort to eventually enable industry is not so clear.

Reviewer 2:

The reviewer stated the proposed future work was presented at a high level; however, it is defined and the work will likely achieve its targets.

Reviewer 3:

The reviewer believed that collaborating with the EverBatt team is critical, although understandably difficult to extrapolate scaled process costs from laboratory work. The reviewer fully supports the proposal to work more closely with 2680 Bipartisan Infrastructure Law (BIL) Funding Opportunity Announcement (FOA) awardees but would further encourage seeking more industry collaborators to validate the prospects of the recycled materials. Scaling the promising processes is a good and necessary next step. As previously noted, it would be useful to understand under which scenario upcycling would be a practical solution. Presumably this would be for EOL batteries of earlier generations. These would typically be mixed in an unpredictable and variable stream. As such, the upcycling parameters would have to be continually modified, and if the approach involves core-shell (for example higher Ni on the exterior) this will not yield a consistent product robust to incoming variations and usable by our industry where variation is the enemy. So again, just because it is possible does not mean that it is practical, and projects should be evaluated judiciously in this manner. Another questionable issue noted under the new projects is the graphite recovery with intact SEI layer. This seems very impractical, as unless the recycled graphite is used exclusively, one would presume that a new SEI adapted to and optimized for specific cell parameters (electrolyte etc.) would be needed. i.e., making a cell using some Gr with SEI mixed with virgin with no SEI seems impractical, as this would result with a cell with 2 potentially different SEI layers post formation.

Reviewer 4:

The reviewer commented that the proposed future R&D is reasonable. Downselecting the processes will be effective for direct recycling batteries. It is one of the important considerations for future so the investigators can focus on a few good solutions rather than pursuing many ideas.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer affirmed that the project supports VTO objectives.

Reviewer 2:

The reviewer stated that the work in this area aligns with the VTO subprogram objectives.

Reviewer 3:

The reviewer expressed some reservations, noting that some of the areas being pursued may not offer practical solutions for the recycling industry. They did acknowledge that important learnings could be applied in material synthesis and separation applications, both within and outside of recycling.

Reviewer 4:

The reviewer commented on the potential cost-effectiveness of direct recycling of battery materials, emphasizing the benefits of lowering the cost of battery materials, reducing the environmental footprint, and improving the supply chain. These factors, they noted, could contribute to lower battery costs and increased adoption of EVs.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that the resources for the project are sufficient to prepare and trial direct recycle materials.

Reviewer 2:

The reviewer mentioned that the resources appear to be sufficient.

Reviewer 3:

The reviewer suggested a slight recalibration of resources toward projects that show more promise of success.

Reviewer 4:

The reviewer noted that the budget for the specific direct recycling project was not identified in the presentation but expressed the belief that there is more than enough funding for this project to achieve its stated milestones in a reasonable timeframe.

Presentation Number: BAT572
Presentation Title: ReCell Center-Advanced Resource Recovery
Principal Investigator: Yaocai Bai (Oak Ridge National Laboratory)

Presenter

Yaocai Bai, Oak Ridge National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 25% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

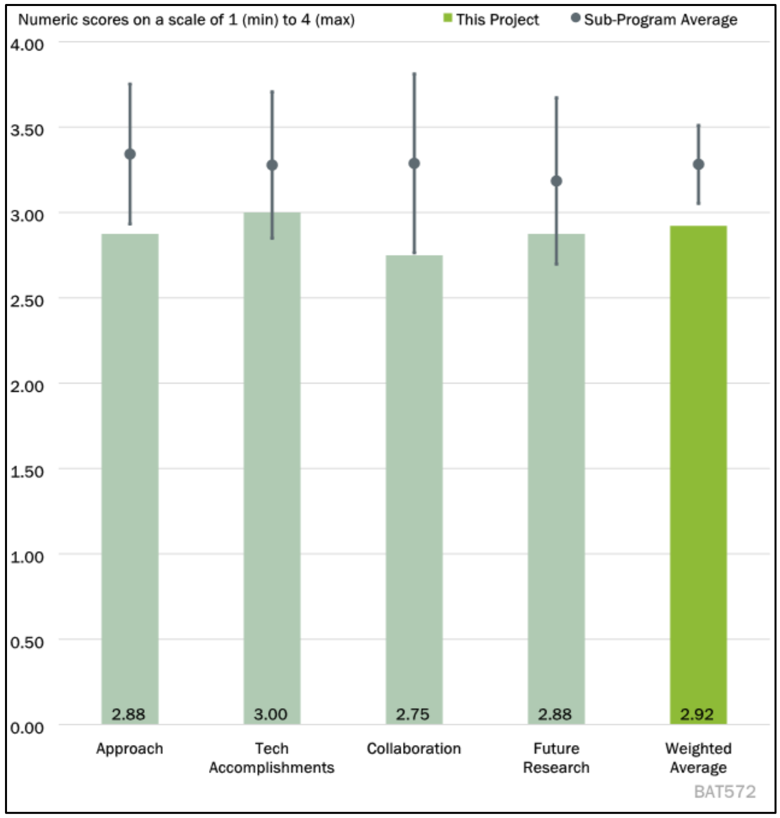

Figure 1-36 - Presentation Number: BAT572 Presentation Title: ReCell Center-Advanced Resource Recovery Principal Investigator: Yaocai Bai (Oak Ridge National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer stated that the approach of exploring multiple new processing paths and ending projects that do not show promise is acceptable. However, they highlighted the potential value of developing engineering data to support optimized equipment and process designs, citing the oil and chemical industry as an example of industries with excellent foundational data for process design.

Reviewer 2:

The reviewer mentioned that there are 11 different projects in this area, all of which seem to be well designed with reasonably planned timelines.

Reviewer 3:

The reviewer emphasized that the project addresses critical needs and takes a fundamental unit operations approach but recommended regular benchmarking with industry/start-ups to ensure that the pursued approaches remain novel.

Reviewer 4:

The reviewer noted that the objectives of this project are not well defined, and limited justification is provided for the selection of subprojects. They mentioned that some of the projects discussed are innovative, while others have already been undertaken by other entities.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer expressed that the technical progress achieved so far is sufficient, noting that many different process routes are being explored, and proof of concepts has been demonstrated.

Reviewer 2:

The reviewer mentioned that most of the projects appear to be in the early stages of research, which is positive progress.

Reviewer 3:

The reviewer raised some concerns about how the presented work relates to the state-of-the-art solutions or approaches pursued by established or start-up companies. The reviewer specifically mentioned the graphite to graphene example and suggested that clarity is needed regarding the suitability of the work for natural or synthetic graphite. If suitable for both and can be used to obtain a normalized output from a variable stream, that would be very compelling. If primarily suited for NG or AG but not both, this should be clearly stated, as it restricts suitability to plant scrap for practical considerations. The reviewer emphasized the importance of industry involvement, acknowledging that it may be easier to engage with industry partners after significant results have been obtained. Still, they stressed the need for early input and engagement from industry to ensure that the research focuses on actual needs and has promise of economic viability.

Reviewer 4:

The reviewer noted that good progress was demonstrated in several sub-projects, such as graphite to graphene and membrane solvent extraction. However, they expressed a desire to see how these sub-projects fit into the overall project plan.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer mentioned that there are various process approaches being studied, but they found it challenging to evaluate the exact level of collaboration based on the provided overview summary.

Reviewer 2:

The reviewer noted that collaboration with laboratories and other entities is generally good.

Reviewer 3:

The reviewer said collaboration is good but expressed concern about the absence of industry partners. They emphasized that engaging industry partners early in the process is essential to ensure interest in the solutions being developed and to increase the likelihood of eventual scaling and commercialization.

Reviewer 4:

The reviewer highlighted that three national laboratories are involved in the 11 sub-projects, and it’s not clear how they work together. They suggested that the projects appear to be led by individual PIs for each laboratory, and there may be a need for better coordination among the laboratories, other consortium partners, and industry stakeholders.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer emphasized the importance of future work involving more interaction with industry partners. They noted that this collaboration is critical to defining the current expectations for extracted metal purification specifications and to isolate which recovery technologies companies would or would not take upon themselves regarding recycling technologies explored. The reviewer also suggested that the role of feedstock variations, particularly from coatings, doping, and degradations of different batteries, should be investigated, as it is an important aspect to consider in recycling processes.

Reviewer 2:

The reviewer commented that the future research outlined in the presentation was somewhat vague.

Reviewer 3:

The reviewer recommended focusing on finding higher value for mixed natural graphite/artificial graphite (NG/AG) graphite streams recovered from battery recycling, addressing challenges related to sodium sulfate, exploring integration opportunities for mixed hydroxide precipitate (MHP) with black mass feedstock, and considering the recycling of LFP batteries given the market's move towards this chemistry. They also suggested benchmarking alternate approaches in the recycling space and involving industry partners more actively.

Reviewer 4:

The reviewer emphasized the need for more specific and targeted future research, down-selecting promising approaches, and increasing collaboration with industry partners to address practical issues and industrialization opportunities.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer expressed agreement with the importance of recovering critical metals.

Reviewer 2:

The reviewer indicated that the project aligns with VTO subprogram objectives.

Reviewer 3:

The reviewer emphasized that the project is relevant to VTO's mission of accelerating electrification, as it contributes to affordable batteries, affordable raw materials, and a domestic supply chain.

Reviewer 4:

The reviewer felt recycling of materials from EOL batteries as an essential part of VTO's Battery R&D efforts, with the potential to reduce the cost of battery EVs, lower the environmental impact of battery mining, and address supply chain concerns. Overall, the reviewer affirmed that this project supports VTO's Battery R&D sub-program objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented on the lack of clear alignment between the shown milestones and advanced metal recovery, making it difficult to evaluate the project's progress in the context of the ReCell project.

Reviewer 2:

The reviewer noted that the resources seem sufficient based on the provided overview.

Reviewer 3:

The reviewer suggested that while the number of projects and resources currently allocated appears reasonable, some projects may need to be reconsidered or replaced in the future if they are not yielding desired results or attracting interest from industrial partners.

Reviewer 4:

The reviewer pointed out that the specific funding allocated to this project is not clear, but the overall funding for the ReCell Center in FY 2022 to FY 2023 is $18.9 million.

Presentation Number: BAT573
Presentation Title: ReCell Center-Design for Sustainability
Principal Investigator: Andrew Colclasure (National Renewable Energy Laboratory)

Presenter

Andrew Colclasure, National Renewable Energy Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 25% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

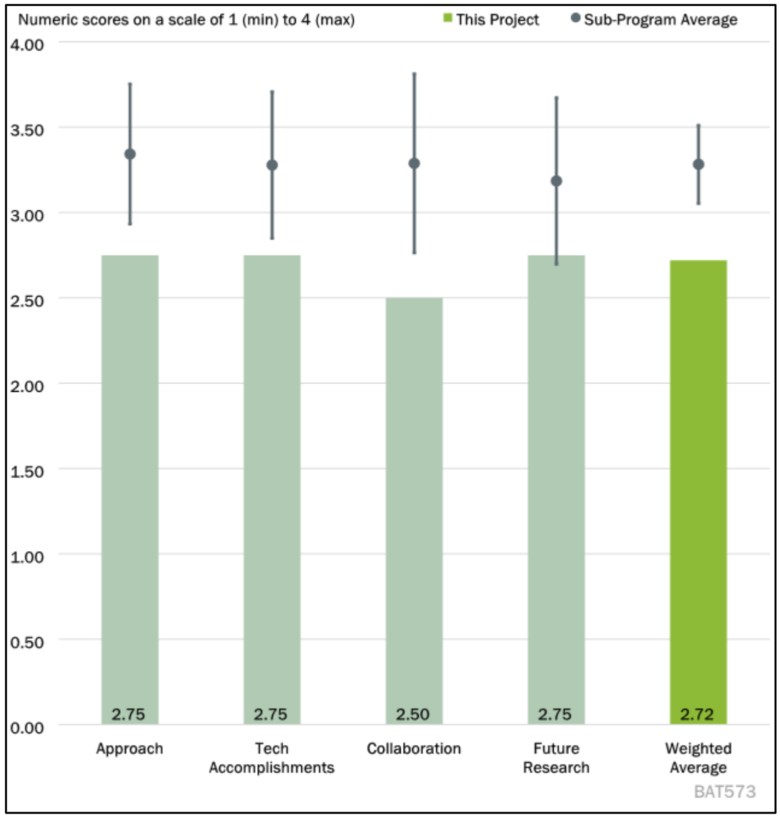

Figure 1-37 - Presentation Number: BAT573 Presentation Title: ReCell Center-Design for Sustainability Principal Investigator: Andrew Colclasure (National Renewable Energy Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer found that the activities aimed at grading a used battery cell and identifying its value for second-life applications were clearly geared towards technical barriers.

Reviewer 2:

In the reviewer’s assessment, some of the projects in this section were currently being worked on by automotive OEMs and battery recyclers. It did not appear that research was done to determine if these topics were already being addressed.

Reviewer 3:

The reviewer noted that while the barriers addressed by the projects were real, it was not apparent that the problems addressed by some of the projects were not better tackled by battery system producers or OEMs, as the solutions were heavily indexed to a particular model/design. Furthermore, the reviewer observed that some of the projects appeared to be developing solutions that may already exist or be in a reasonably advanced TRL and being developed by companies (often in conjunction with OEMs) or recyclers. To maximize the usefulness of the work, the reviewer recommended an intensive survey of the current status of the industry (including startups) solutions. Ideally, ReCell could engage with some potential users of the techniques being studied, both to confirm that there is a need for new solutions and to ensure that the work by ReCell and participating laboratories is guided by the practical barriers relayed by the industry stakeholders. The reviewer also provided specific comments on a few of the projects/research areas:

Regarding (end-of-life) EOL cell passivation by heat treatment, the reviewer pointed out that the practical difficulty of placing an entire pack into a heating chamber should be considered, especially with increasing size of EV batteries. The reviewer noted that companies were developing deep-discharge technology (electrical discharge) that is likely more practical.

Concerning BTM second use, the reviewer emphasized that this is highly specific to a given battery design, and solutions must be developed in conjunction with OEMs who might ultimately be liable. The reviewer also mentioned that home storage may be a higher-risk application relative to other possible second-life applications.

On the topic of PV Si recovery, the reviewer mentioned that there does appear to be a need to find recycling solutions for PVs. In this case, the reviewer suggested that rather than conducting small-scale studies looking at the impacts of contaminants, the focus should be on developing processes to remove the contaminants. The reviewer pointed out that the presence of contaminants (likely in fluctuating amounts) would introduce variability, which would preclude use in highly engineered battery materials.

In the area of ML for SOH determination, the reviewer noted that OEMs know how to determine and evaluate SOH and will communicate results to trusted certified partners. The reviewer also raised questions about whether many startups were working on various techniques (EIS, acoustics, etc.) and whether these had been extensively benchmarked. The reviewer expressed some concern regarding the controller area network.

Regarding robotic disassembly, the reviewer commented positively on the idea of developing a database of fastener/joining types and recommended separation/dismantling techniques. The reviewer suggested that cell-level replacement would be highly unlikely (value not justified by complexity and cost). For diagnostics, the reviewer recommended comprehensive scouring of available tech and startups working in this area, citing examples such as Feasible, Voltaiq, ReJoule, B2U, Smartville, etc., to ensure the novelty of work.

Reviewer 4:

The reviewer observed that there seemed to be no cohesive overarching goals and objectives discussed for Design for Sustainability Projects. The reviewer found that the approach discussed was generic for the ReCell projects. The reviewer appreciated the addition of second use and handling of EOL batteries, considering it important, and noted that it was missing in the first phase of ReCell; it was good that they had been added. The reviewer concluded that it did not seem that the PV Si recovery was a fit for ReCell. The reviewer pointed out that the use of Si still had not entered the electric commercial vehicle market, and because of life limitations, it may be several years before entering the market. The reviewer suggested that the recovered Si from PV could go back to the production of PVs, but the cost of this approach compared to existing practices of making Si was not discussed.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer observed that some efforts appeared to be further along than others in terms of development and usefulness; however, overall, the technical progress seemed acceptable.

Reviewer 2:

According to the reviewer, the projects were initiated recently, and there was little to no progress to consider at this point in time.

Reviewer 3:

The accomplishments listed on Slide 19 were deemed reasonable by the reviewer, but the level of detail provided was insufficient to support a higher ranking.

Reviewer 4:

The reviewer noted that no project plan had been discussed, making it challenging to make comparisons. It appeared that there were several individual, unrelated sub-projects within the overall initiative. The technical achievement for the end of ML for SOH and remaining useful life was considered notable.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer remarked that the presenter mentioned working with some industry partners for feedback and acknowledged the ongoing effort to avoid duplicate efforts with the industry.

Reviewer 2:

The reviewer commented that there did not seem to be much discussion or interaction with the industry in some of the projects in this area. As previously stated, automotive OEMs and others in the industry are already working on some of these topics.

Reviewer 3:

The reviewer praised the collaboration with academia and national laboratories but recommended an increased effort to collaborate more extensively with industry.

Reviewer 4:

The reviewer observed that the project appeared to have several sub-projects that did not require coordination among other partners, and there seemed to be no collaboration with the industry in these sub-projects.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer emphasized that if findings were disseminated effectively, the TEA and methods for battery diagnostics could prove highly beneficial. The reviewer pointed out a noteworthy omission, suggesting that the team consider focusing on guidelines and innovations to protect workers involved in handling, installing for second use, or dismantling battery packs.

Reviewer 2:

In the reviewer’s assessment, the project presented a clear definition of future work and appeared capable of achieving its targets.

Reviewer 3:

Regarding the topic of cell passivation, the reviewer advised against allocating excessive effort to it. Instead, the reviewer recommended exploring potential solutions targeted at EV or array-level applications. The reviewer acknowledged the feasibility of early testing with cells but stressed the importance of outlining a clear path toward larger assembly suitability. Concerning photovoltaic (PV) contaminants, the reviewer stressed the significance of addressing them, noting that Resource Material developers were unlikely to compromise on lower-grade materials/contaminants. The recommended focus, according to the reviewer, should center on the removal of these contaminants. When discussing Battery-as-a-Service (BaaS) and advanced diagnostics, the reviewer questioned whether collaboration with companies already active in this field was possible. The reviewer recommended separating the assessment of TEA for second use versus recycling by chemistry, specifically distinguishing between NMC/NCA and LFP.

Reviewer 4:

Regarding cell disassembly and electrode separation, the reviewer suggested that this approach could prove useful for solid-state chemistry structures. In conclusion, the reviewer found the proposed future work to be reasonable.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The project was noted by the reviewer to support the VTO mission.

Reviewer 2:

In response to whether VTO subprogram objectives are supported by this project, the reviewer affirmed that they are.

Reviewer 3:

The reviewer added that this support is somewhat marginal, given that many of the areas of focus might be more effectively pursued by industry.

Reviewer 4:

The reviewer emphasized that the project is relevant to the VTO Battery R&D Recycling project, as it aims to lower the cost of batteries through recycling and reuse.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer expressed concerns that the remaining milestones do not seem to relate closely to the work presented. The reviewer suggested that it might be beneficial to define more sub-project-specific milestones.

Reviewer 2:

Regarding resources, the reviewer noted that they appear to be sufficient to meet milestones in a timely fashion.

Reviewer 3:

The reviewer mentioned that it is not clear how much of the total funding is allocated to this group of projects.

Reviewer 4:

The reviewer pointed out that only the overall funding for the ReCell Center is provided, which is $18.9 million for FY 2022-FY 2023. The specific funding allocation for this project is not clear.

Presentation Number: BAT574
Presentation Title: ReCell Center-Modeling and Analysis
Principal Investigator: Allison Bennett Irion (Argonne National Laboratory)

Presenter

Allison Bennett Irion, Argonne National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 25% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

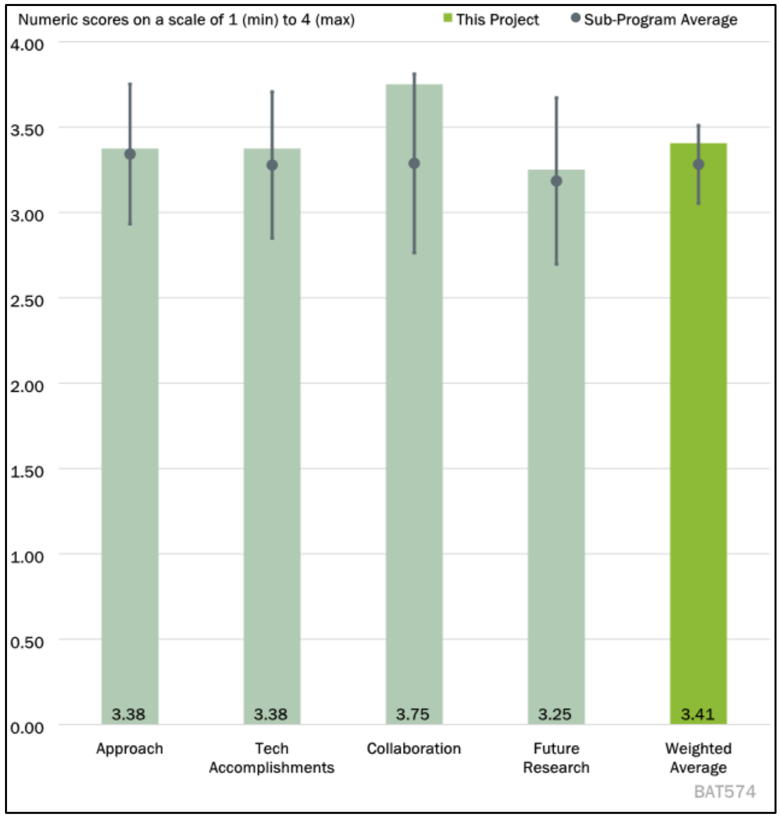

Figure 1-38 - Presentation Number: BAT574 Presentation Title: ReCell Center-Modeling and Analysis Principal Investigator: Allison Bennett Irion (Argonne National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer acknowledged that the tools being developed for recycling process evaluation will be helpful in determining areas of need and assessing the potential impact of new technologies.

Reviewer 2:

In general, the reviewer noted that the various models presented address the need to compare and understand costs related to battery recycling, assess impacts on the supply chain, and understand cell performance. The projects in this area were designed to support other projects and have met that requirement in a timely manner.

Reviewer 3:

While most of the projects were deemed very valuable with impressive progress, the reviewer found it challenging to assign general comments to such a mixed set of topics being modeled. The reviewer then provided specific comments by category of projects:

For the higher-level projects aimed at supply chain analysis, cost assessment, overall recycling, separation processes, and resource assessment (e.g., EverBatt, LIBRA, GCMat, AMUSE), the reviewer found them practical and powerful. The completion of these projects could provide a valuable resource for the industry.

However, some of the efforts focused on developing models to study the impacts of artifacts from direct recycling, such as imperfect separation of cathode materials, were considered to have very little value. The premise that direct recycling is a suitable solution for EOL batteries, from which this fluctuating mixture would originate, has been challenged repeatedly. Most experts acknowledge that if direct recycling has a role, it would primarily be for plant scrap with consistent cathode chemistry. The reviewer suggested that unless ReCell can find global cell/cathode producers advocating for introducing inconsistency and associated risks of inconsistent cathode materials, especially for automotive applications, this work should be reevaluated.

Similarly, for upcycling, the reviewer questioned its practicality. While it is technically possible to upcycle a known and discrete lower Ni-NMC to a higher Ni one in the laboratory, the reviewer raised concerns about how to handle large and ever-fluctuating incoming blends and generate uniform upcycled materials lot after lot. The reviewer indicated that this may not be a practical solution for automotive/EOL applications. However, the reviewer also noted that if the learnings from these efforts can inform general cathode synthesis work, there may be some value in terms of better understanding underlying thermodynamics, kinetics, interdiffusion, and so on.

Reviewer 4:

The reviewer found these plans to be clear and categorized their comments accordingly.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer noted that the models under development are valuable for evaluating the techno-economic prospects of recycling technologies. The inclusion of a solvent extraction model in the study was appreciated, as it can contribute to scale-up and process design optimization.

Reviewer 2:

In terms of technical accomplishments, the reviewer observed that they supported current ongoing projects and improved existing software models.

Reviewer 3:

The reviewer provided a rating that represents an average of the higher and more relevant accomplishments achieved in the projects, excluding upcycling and cathode mixture effects. The latter was viewed as less relevant to solving the large-scale needs of the recycling ecosystem. The reviewer suggested that unless it can be demonstrated that direct recycling has a real opportunity for EOL batteries, which will be the dominant feed-source in about 10 years, the work should focus mostly on manufacturing scrap. In such cases, upcycling and mixed cathode problems are less prevalent, and related modeling efforts have limited value. However, the reviewer found the EverBatt, LIBRA, GCMat, and AMUSE work to be very promising, practical, and valuable. The reviewer recommended making more efforts to disseminate information about these tools to encourage their use.

Reviewer 4:

The reviewer concluded by noting that the progress of the projects is in line with the plan.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer observed that the models appear to be designed with other project models in mind, and it seems that the project team is making efforts to minimize overlap with tools under development.

Reviewer 2:

The reviewer noted good collaboration across project teams, which is seen as valuable for maximizing integration, synergy, and cross-functional learning among EverBatt, LIBRA, and GCMat tools.

Reviewer 3:

The reviewer highlighted the “great” collaboration among various ReCell members and industry partners.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer noted that most of the future work appears to heavily emphasize the application of existing models to different recycling scenarios. The reviewer raised a question about the importance of measuring tortuosity and NMC particle cracking in future work. It was pointed out that results may vary depending on cell manufacture and cell use history, and the reviewer did not see a clear connection between having that data and achieving lower-cost recycling or improved ability to address varied recycle streams.

Reviewer 2:

The reviewer affirmed that the purpose of the work continues to support the overall goals of ReCell.

Reviewer 3:

Regarding proposed future work, the reviewer found it well designed and relevant to the mission of ReCell.

Reviewer 4:

The reviewer noted that the proposed future plans are clearly defined.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer confirmed that the project supports the VTO objectives.

Reviewer 2:

The reviewer stated that the project supports the overall VTO objectives.

Reviewer 3:

The reviewer noted that the projects assembled within this group are mostly highly relevant and applicable to VTO subprogram objectives. However, the reviewer reiterated the previous critique, both in this section and other subprogram groupings, concerning the allocation of high amounts of resources and time to study aspects of direct recycling that would only be applicable to EOL batteries as opposed to manufacturing scrap. This was the only negative feedback provided.

Reviewer 4:

The reviewer acknowledged that the model developed in this project helps identify cost-positive recycling technologies in support of the VTO Battery R&D recycling and reuse program.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer found that the models under development appear to be useful for policy makers and industry in evaluating recycling options. The team seems prepared to meet the remaining modeling milestones, though there could be potential delays if the experimental side takes longer than expected to generate the necessary information.

Reviewer 2:

In terms of resources, the reviewer assessed that they appear to be sufficient to achieve the milestones in a timely manner.

Reviewer 3:

The reviewer reiterated the previous point regarding the allocation of resources to studying the impact of mixed cathodes on performance and upcycling. These efforts, while possibly of academic interest, were considered to address problems with little application in the industry, particularly when applying direct recycling to the challenging case of EOL batteries. The reviewer pointed out that battery manufacturers are unlikely to willingly introduce a potential source of variability into their processes, especially considering the availability of increasingly sustainable and efficient recycling processes capable of producing uniform, consistent materials with high purity levels from highly variable feeds.

Reviewer 4:

The reviewer noted that only the overall funding for the ReCell Center is shown ($18.9 million for FY 2022 to FY 2023), and it is not clear how much funding is specifically allocated to this project.

Presentation Number: BAT575
Presentation Title: eXtreme Fast Charge Electrolyte Development Thrust
Principal Investigator: Bryan McCloskey (Lawrence Berkeley National Laboratory)

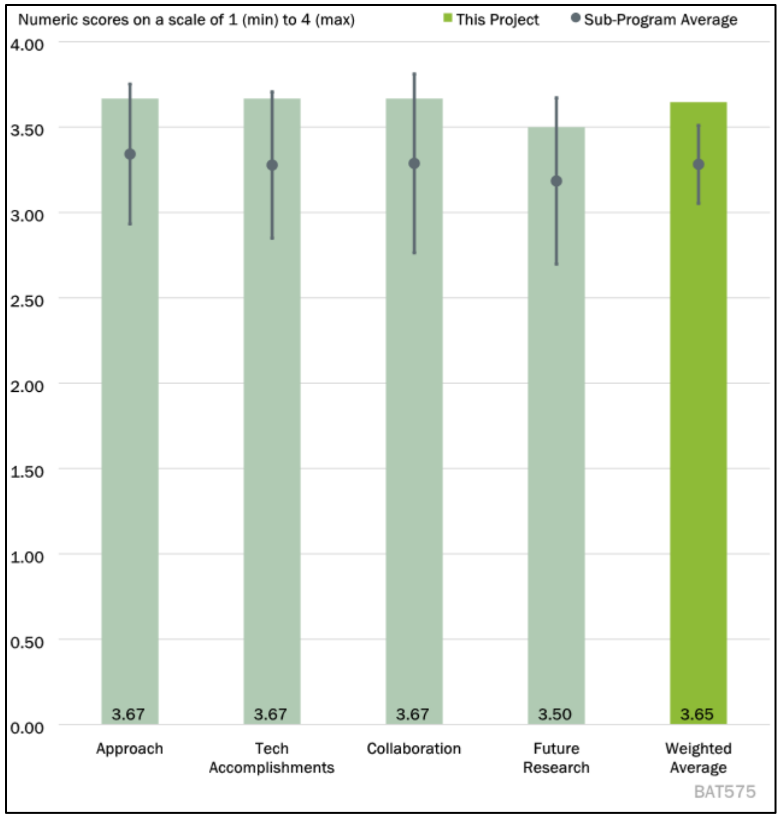

Figure 1-39 - Presentation Number: BAT575 Presentation Title: eXtreme Fast Charge Electrolyte Development Thrust Principal Investigator: Bryan McCloskey (Lawrence Berkeley National Laboratory)

Presenter

Bryan McCloskey, Lawrence Berkeley National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer noted that the effort of this project aligns with the DOE goals by focusing on developing electrolytes with enhanced thermal stability, reducing cell impedance (both bulk and interfacial), and eliminating the formation of dead Li for XFC realization. The technical challenges related to electrolyte performance under XFC conditions are being addressed.

Reviewer 2:

The reviewer pointed out that electrolyte studies aimed at improving fast charging are considered a major enabler that is being explored in the automotive industry. The reviewer expressed excitement about the continued progress in this area. Additionally, the reviewer found Li solvation studies interesting and suggested that more temperature conditions should be explored.

Reviewer 3:

The reviewer commented that the project’s primary focus is on electrolyte improvement, and it employs various approaches, such as dual salt, high ester, and high salt concentration, to accelerate ion transport across the cell.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer mentioned that dual salt electrolytes have been identified to improve plating reversibility and charge acceptance at high C-rates. Specifically, the use of LiFSI/ester co-solvent was noted to lead to improved conductivity and improved interfacial properties, resulting in reduced Li plating.

Reviewer 2:

The reviewer noted that the dual salt study and high concentration studies have shown some continued progress and suggested that the effect on high-density electrodes should be the next focus.

Reviewer 3:

The reviewer mentioned that certain improvements were achieved with the new electrolyte composition. Notably, Li^0 deposition was apparently reduced in dual salt and ester-based electrolytes. The reviewer highlighted a novel electrospray ionization mass spectrometry (ESI-MS) study conducted at various temperatures, which allowed for the plotting of solvation activation energy. This was considered very helpful in understanding the electrolyte properties under extreme conditions.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer praised the successful collaboration across the team, which led to good research progress.

Reviewer 2:

The reviewer emphasized that collaboration and coordination across the project teams were outstanding.

Reviewer 3:

The reviewer stated that the projects were highly collaborative, reflecting the effective teamwork within the research efforts.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer found that the proposed future work is well illustrated. The reviewer suggested that it might be of interest to explore the impact of the new electrolyte on battery calendar life and battery performance at different temperatures. Additionally, considering technology transition and establishing connections with battery OEMs and/or battery components suppliers may be useful, especially as the research is in the first year of the project.

Reviewer 2:

The reviewer noted that the proposed future work aligns with the overall scope of the project and emphasized the importance of identifying degradation mechanisms as various enablers are studied, highlighting its critical role in achieving success.

Reviewer 3:

The reviewer expressed optimism about the further study of new electrolyte systems, particularly those developed by B500 for lithium metal batteries (LMBs) and found the direction to be very promising.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer emphasized that the development of electrolytes to support XFC is an integral part of the efforts to realize the VTO goals, particularly within the XCEL program.

Reviewer 2:

The reviewer expressed that this project is extremely relevant to the adoption of electrification on a large scale.

Reviewer 3:

The reviewer considered this project to be highly relevant in the context of achieving VTO goals and the broader adoption of electrification.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer found that the funding level and timeframe appear to be sufficient to support the research on electrolyte research to a level that demonstrates the capability of the technique.

Reviewer 2:

The reviewer noted that the funding planned for this project is deemed sufficient to achieve the proposed goals.

Reviewer 3:

The reviewer assessed the funding as sufficient for the research efforts in this project.

Presentation Number: BAT576
Presentation Title: Solid State Batteries with Long Cycle Life and High Energy Density
Principal Investigator: Haegyum Kim (Lawrence Berkeley National Laboratory)

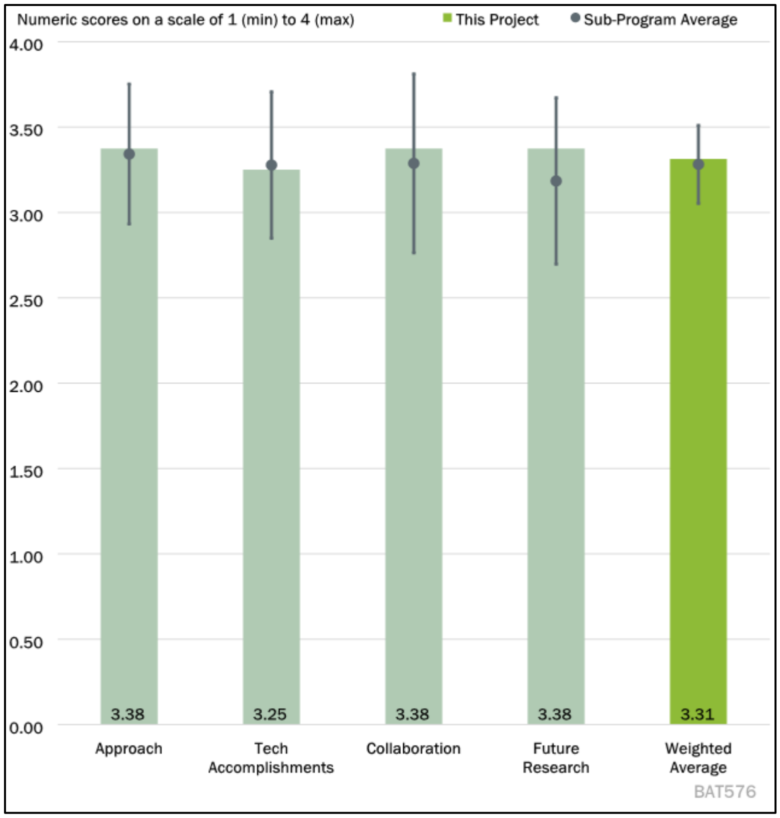

Figure 1-40 - Presentation Number: BAT576 Presentation Title: Solid State Batteries with Long Cycle Life and High Energy Density Principal Investigator: Haegyum Kim (Lawrence Berkeley National Laboratory)

Presenter

Haegyum Kim, Lawrence Berkeley National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer found that, after reviewing the Approach to Performing the Work, the technical barriers are mostly addressed successfully, and the project is properly designed. The group has outlined reasonable methods to overcome the tasks, identified potential issues within their systems, and proposed specific strategies to solve them. They have planned various experiments and testing to demonstrate an excellent outcome.

Reviewer 2:

The project aims to create a protective layer on the Li anode, between the Li anode and SSE. Metal-based protective layers and SSE polymer composites have been reported as part of this approach. The reviewer commended the project’s approach to mitigating Li dendrite growth by engineering a protective layer. However, the reviewer suggested that the PI carefully investigate the impact of the metal layer, especially those with large differences in physical properties, such as hardness, and potential differentials compared to Li metal. Additionally, the PI should be mindful of SSE reactions with polar and/or protonic solvents.

Reviewer 3:

The reviewer stated the project aims to address critical challenges facing SSBs, primarily through electrode and interface design. The reviewer noted that the project team has a good combination of expertise and a well-structured project plan with a reasonable timeline.

Reviewer 4:

The reviewer mentioned that the proposed work directly addresses the barriers present in SSBs. The project is well designed, and the combined efforts of scientists with different expertise are coordinated effectively. The proposed tasks cover anode interface, high voltage stability, SSE membrane, cathode thickness, and the scale-up issue of SSEs, all of which are crucial aspects of SSBs. The timeline is considered reasonable, provided that all proposed tasks are successful.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer noted that the team has presented a clear roadmap toward their final target and distributed their workload evenly within a suitable timeline. The team has managed to accomplish their work on time and has made good progress. The project plan is reasonably planned, and the milestones align with the project's objectives. However, the reviewer suggested that it could be beneficial to account for potential issues that may arise in future studies.

Reviewer 2:

Regarding the evaluation of different metal protective layers, the reviewer mentioned that tin (Sn) and silver (Ag) were found to be effective. Polymer SSE composites were synthesized and tested in a symmetric cell. The reviewer recommended that the PI test the SSEs in a full cell and cycle it for a longer duration to further assess their performance.

Reviewer 3:

The reviewer acknowledged that the team has made good progress in multiple directions. However, they also noted that there is still some room for improvement in battery performance.

Reviewer 4:

The reviewer highlighted the positive progress made, such as the development of an active buffer layer to stabilize the interface between Li and SSE. The PIs have discovered interesting clues that they plan to further explore. The halide solid electrolyte has also demonstrated reasonable high voltage stability on the cathode side. The reviewer suggested that, in addition to the current modeling work, the PI may consider using modeling to understand existing materials and their interfaces/interphases. Additionally, the cost of adding graphene oxide in the cathode should be considered.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer noted that collaboration within the project team is strong, and the work is well-distributed. It appears that there may not be a need for more collaboration, as roles and responsibilities are clearly defined. The cross-functional cooperation and communication among team members are cohesive, demonstrating a commitment to accomplishing the project's goals.

Reviewer 2:

The reviewer stated the PI has collaborated with colleagues at LBNL and universities. The reviewer recommended that the PI emphasize the results of this collaboration in their work.

Reviewer 3:

While the team has adequate collaborations within the project team, the reviewer mentioned that it's not entirely clear from the presentation what specific contributions each team member made in the reviewed fiscal year.

Reviewer 4:

The reviewer noted that the project team is well-coordinated within LBNL but observed that there is no industry partner for this project. Additionally, the modeling work appears to be separate from the presentation, and the reviewer suggested that more experiments are needed to support the modeling efforts.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer found that the future work aligns with the project plans, and some of the updated data show clear and promising results that can strongly support their future studies. However, the reviewer suggested that it would be beneficial to have more detailed characterization results or materials structure information for progress monitoring.

Reviewer 2:

The reviewer recommended that the PI should focus more on a specific system, as it appears that they are trying to cover too many areas in the coming year.

Reviewer 3:

The reviewer noted that the proposed future research is clearly defined. It was suggested that the team should develop a plan to standardize the electrochemical measurements, including cell pressure.

Reviewer 4:

In terms of future work, the reviewer suggested that the team may consider starting with relatively thin cathodes before moving on to very thick cathode structures.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer emphasized that the project shows strong relevance to the VTO goals and supports its objectives. The project's impact on energy development and sustainability is evident, and it has a clear influence on VTO's program, making it likely to support their objectives.

Reviewer 2:

The reviewer stated the prevention of lithium dendrite growth was relevant to the overall VTO subprogram objectives by the reviewer.

Reviewer 3:

The reviewer noted that the project is highly relevant to the overall goals of VTO programs.

Reviewer 4:

The project's focus on interfaces and materials/electrode-level research was seen by the reviewer as supportive of overall VTO subprogram objectives. The fundamental research conducted in this project was also regarded as good.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer found that the resources of the project appear to include a dedicated workforce with the necessary expertise to execute the project. The anticipated scope and stated milestones were considered reasonable and achievable. The reviewer believed that the sufficient resources from this team should enable them to accomplish their goals and address potential technical challenges in future studies.

Reviewer 2:

The reviewer mentioned that the PI has sufficient resources to conduct the proposed research.

Reviewer 3:

The reviewer noted that the team has enough resources and funding to make great progress in this project. However, they recommended that the team consider including some industry collaborations, possibly through sample exchange, to enhance their research efforts.

Reviewer 4:

The reviewer stated that LBNL has all the resources needed for this fundamental research.

Presentation Number: BAT577
Presentation Title: Low-Pressure All-Solid State Cells
Principal Investigator: Tony Burrell (National Renewable Energy Laboratory)

Presenter

Annalise Maughan, Colorado School of Mines

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

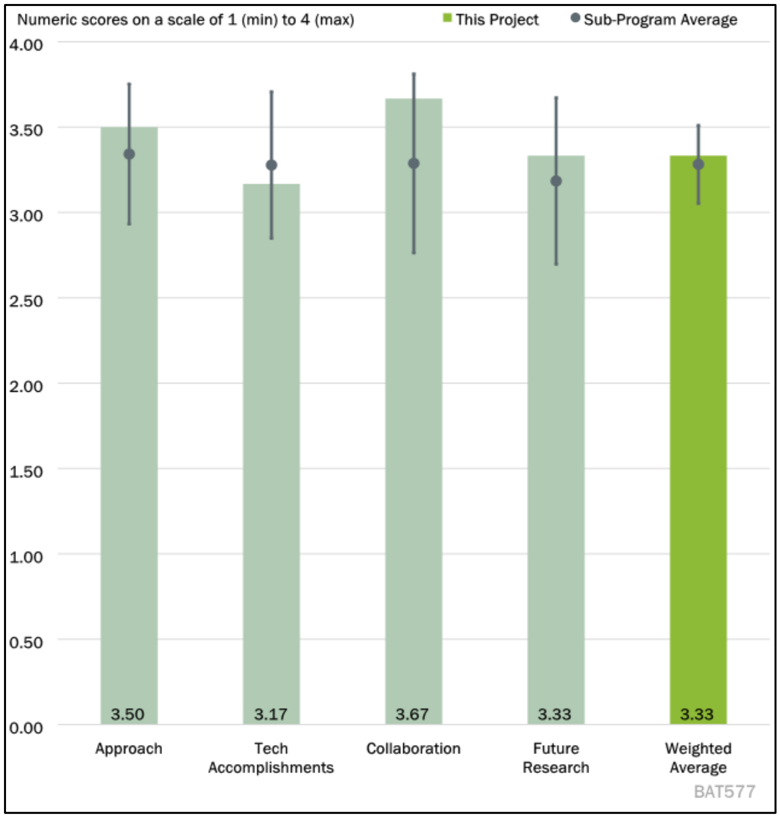

Figure 1-41 - Presentation Number: BAT577 Presentation Title: Low-Pressure All-Solid State Cells Principal Investigator: Tony Burrell (National Renewable Energy Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer noted that the approach undertaken by the team is multi-pronged and well-designed to achieve the technical goals. However, they suggested that more focus should be placed on testing materials in device configurations compared to idealized scenarios.

Reviewer 2:

The technical barrier was considered to have been effectively addressed, and the reviewer commended the collaboration among materials development, characterization, modeling, and cell design. The project was seen as demonstrating a well-thought-out design, and the timeline was viewed as reasonable and feasible.

Reviewer 3:

Overall, the reviewer cited the team's objective is to achieve high-energy-density, low-stack-pressure SSBs by focusing on: (1) tuning the chemistry of current state of the art in argyrodite-based solid electrolytes (ASEs); (2) interface modification, and (3) *operando* testing and characterization. The reviewer also highlighted that the team is well-integrated, working on synthesis, interfacial characterization, electrochemical testing, and cell fabrication.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer stated that in their plans for FY 2023, the research team included the development of SEs and interface modifiers, as well as the investigation of pressure-dependent transport and *in situ* characterizations. The team reported that the conductivity of the SEs synthesized is high. However, they mentioned that the interfacial additive has fairly low conductivity, which might pose a challenge. They also noted progress in the *in situ* analysis of interface evolution.

Reviewer 2:

The reviewer pointed out that the report did not include information on the conductivity of lithium carbonate. They mentioned that the interfacial issue of the electrolyte against Li metal was investigated using XPS.

Reviewer 3:

The reviewer commended the team for making very good progress toward their FY 2023 objective of tuning the argyrodite chemistry to achieve higher IC. This was achieved by substituting P with Sb and Ge, which is related to Li interstitials and cation disorder. The *in situ* XPS method for studying the SEI of ASE (all-solid electrolyte) with Li metal was considered interesting. However, the reviewer expressed curiosity about whether the effect of the EB charging could create charge accumulation or local effects that might shift the reaction pathways differently from real electrochemical and chemical effects under working conditions. The reviewer asked if any new insights had been gained in this regard. The decomposition products observed were noted to be similar to what had been reported earlier for Li_6PS_5Cl. The reviewer inquired about the origin or source of the oxygen contamination. The team's approach of using a sulfonated polymer coated Li_6PS_5Cl (LPSCL) was considered interesting. The reviewer asked if the polymer layer has Li-ion conductivity and what the typical interfacial resistance between the polymer phase and the solid electrolyte is. They also raised questions about the intrinsic reasons for the current density not exceeding 200 $\mu A/cm^2$ in a symmetric cell measurement for the Sb-Ge composition and what approaches the team is considering to address this issue.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer suggested that the project can begin leveraging its collaboration with NREL to test the materials developed in a device setting, as that is where most bottlenecks are anticipated to arise.

Reviewer 2:

The reviewer noted that there is cooperation among the material development group, cell design and build group, and advanced characterization group, indicating teamwork and collaboration within the team.

Reviewer 3:

The reviewer mentioned that there are no external collaborators at present.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer commented that the end goal of achieving a 2 Ah cell working at less than 1 MPa pressure sounds aggressive, especially with thicker cathodes. They suggested that the team should consider expanding pressure-dependent transport measurements to composite cathodes as well as anodes to identify potential bottlenecks.

Reviewer 2:

The reviewer remarked that the proposed future research is an extension of the current research, and the purpose is clarified.

Reviewer 3:

The reviewer stated that the team has clearly defined goals and metrics as part of future research. These goals include the integration of highly conducting solid electrolyte for full cell testing and testing the solid electrolyte with a working Ni-rich cathode.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer affirmed that the program is aligned with VTO goals.

Reviewer 2:

The reviewer commented that the project aims to develop a high ionic conductive and stable electrolyte against Li, which can support all-SSBs with high energy density. Therefore, the project was seen as supporting the overall VTO subprogram objectives.

Reviewer 3:

The reviewer stated that the project goals are directed towards developing SSBs with energy density exceeding 500 Wh/Kg for EVs.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer affirmed that the resources are adequate for this project.

Reviewer 2:

The reviewer expressed that there are sufficient resources to complete the project, including material design, characterization, modeling, and electrochemical performance tests.

Reviewer 3:

The reviewer stated that the project is funded at an appropriate level for delivering towards milestones and deliverables.

Presentation Number: BAT578
Presentation Title: Stable Solid-State Electrolyte and Interface for High-Energy Density Lithium-Sulfur Battery
Principal Investigator: Dongping Lu (Pacific Northwest National Laboratory)

Presenter

Dongping Lu, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 80% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 20% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

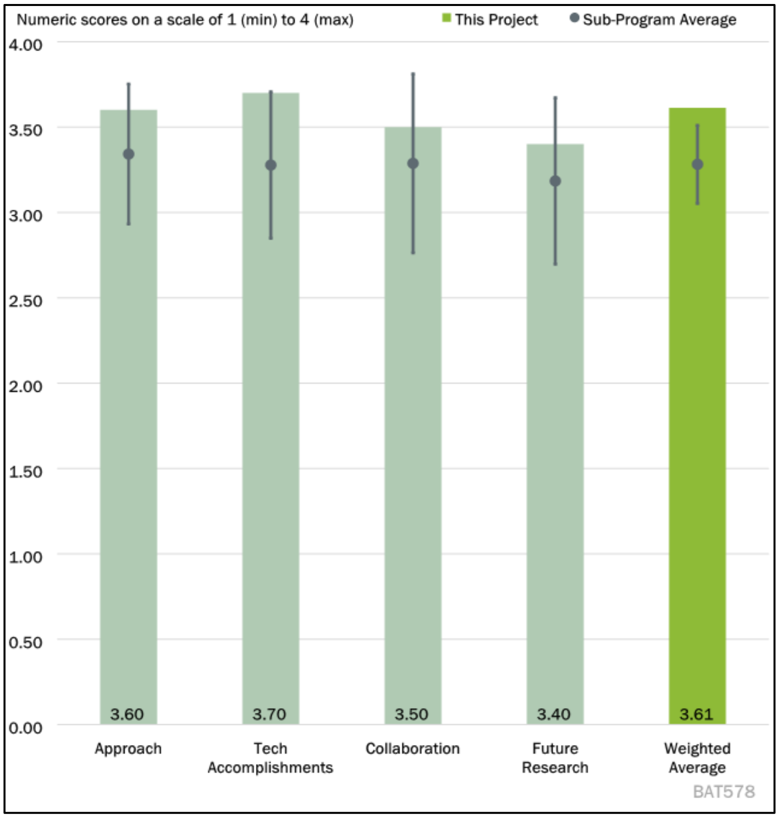

Figure 1-42 - Presentation Number: BAT578 Presentation Title: Stable Solid-State Electrolyte and Interface for High-Energy Density Lithium-Sulfur Battery Principal Investigator: Dongping Lu (Pacific Northwest National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer noted that the technical accomplishments to date include the synthesis and testing of a SSE, demonstration of symmetric Li cell cycling, and performance of an all-solid-state Li-S cell using a solid electrolyte. Additionally, the fabrication and processing of sulfur cathode sheets were achieved. These technical accomplishments address barriers related to solid-state IC and stability with Li metal anodes. The reviewer found the timeline and progress to date to be reasonable.

Reviewer 2:

The reviewer stated that the project's research plan was excellent, with progress made toward resolving critical challenges facing solid-state Li-S batteries. The project's design and experimental execution timeline were also commended.

Reviewer 3:

The reviewer stated that the technical barrier of achieving good Li interfacial stability for solid-state Li-S batteries has been effectively addressed. The long-term cycling of all-solid-state Li-S cells has been achieved, reflecting a well-thought-out design with a reasonable and feasible timeline. However, there was a mention that the demonstration for the cathode configuration was not entirely clear.

Reviewer 4:

The reviewer stated the project's focus is on addressing low IC of solid electrolytes, poor Li/solid electrolyte stability, low sulfur utilization, and limited cycle life in all-solid-state Li-S batteries. The design and synthesis of novel SSEs to overcome these challenges were deemed well-planned.

Reviewer 5:

The reviewer highlighted the project's alignment with the goals of the B500 program, aiming to develop SSEs with high IC and Li interfacial stability, improved sulfur utilization, and scalability for integration into all-solid-state Li-S batteries. The project was considered well-aligned with DOE goals for high-energy and long-life batteries for EVs. However, the reviewer also pointed out some weaknesses, including the lack of quantitative milestones in the project's progress representation, such as specifying the thickness of the ultra-thin layer in milestone 3 and the limits of external pressure targeted in milestone 4. The reviewer suggested providing a projected timeline to meet the B500 goals of 500 Wh/kg and 1000 cycles based on the current approach.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer stated that the project had achieved several technical accomplishments in the past year. These accomplishments included the synthesis and testing of a SSE, the demonstration of symmetric Li cell cycling, and the performance of an all-solid-state Li-S cell using a solid electrolyte. Additionally, the project had made progress in the fabrication and processing of S cathode sheets. The reviewer found these technical accomplishments to be relevant to addressing the technical barriers related to solid-state IC and stability with Li metal anodes. Furthermore, the reviewer considered the project's timeline and progress to be reasonable.

Reviewer 2:

The reviewer remarked that the project's research plan and progress in addressing critical challenges facing solid-state Li-S batteries were deemed excellent. The project was well-designed and had a well-thought-out experimental execution timeline.

Reviewer 3:

While the technical barrier related to solid electrolyte had been effectively addressed, the reviewer mentioned that the interlayer mentioned in the project plan had not been clearly illustrated in the evaluation. Additionally, the operation of the 2 mAh/cm^2 cycle at 100°C was considered unpractically high, although the performance of full cells was described as surprising and interesting.

Reviewer 4:

The reviewer observed that in the past year, the project had achieved three main advancements, including the synthesis of a $Li_7P_2S_8Br_{0.5}I_{0.5}$ solid electrolyte with high IC, improved cycling stability of all-SSBs with high areal capacity and sulfur loading, and progress in the development of all-solid-state Li-S pouch cells through dry processing.

Reviewer 5:

The reviewer found the project's technical accomplishments and progress to be promising for long-life Li-metal based solid-state cells. However, they questioned some "weaknesses" in the evaluation, including the lack of detailed information on the composite cathode, particularly concerning achieving good sulfur utilization with high loadings and low proportions of catholyte. Additionally, it was not entirely clear whether the project exclusively used SSEs or if any liquid electrolyte was employed for interfacial purposes.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer commented on the collaboration within the project, noting that it involved collaboration between PNNL, the University of Wisconsin at Milwaukee, and Thermo Fisher. They suggested that highlighting the role of the partners in technical accomplishments would directly emphasize the importance of collaborative efforts.

Reviewer 2:

The reviewer expressed satisfaction with the collaboration network developed by the team and did not offer any comments on additional collaborations.

Reviewer 3:

The reviewer observed cooperation among the material development group and advanced characterization group. They also mentioned that the thin film cathode and SSE were developed by the University of Wisconsin at Milwaukee.

Reviewer 4:

The reviewer stated that the project involved researchers from the universities, national laboratories, and industry, all of whom brought complementary expertise to the collaboration. They found the collaboration to be effective in advancing the project.

Reviewer 5:

The reviewer noted that there were ongoing collaborations within PNNL for characterization and modeling, as well as external partnerships with the University of Wisconsin at Milwaukee for separator/electrode processing and Thermo-Fisher Scientific for electrode characterization.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer commented on the future work of the project, noting that while it lists general high-level goals to address technical challenges and barriers, it could benefit from more specificity in the approach to these ongoing goals.

Reviewer 2:

The reviewer expressed satisfaction with the team’s future research plan and did not identify any weaknesses in it.

Reviewer 3:

The reviewer stated that the proposed future research is an extension of the current research and that the purpose is clarified.

Reviewer 4:

The reviewer highlighted that the project aims to further improve the performance of all-solid-state Li-S batteries through various approaches, including constructing Li or SSE interlayers, optimizing Li cycling pressure, understanding Li nucleation and growth, identifying optimal sulfur host materials, and optimizing dry processing for separator or electrode fabrication. They believed these efforts were likely to address the remaining challenges.

Reviewer 5:

The reviewer acknowledged that there are still significant challenges with all-solid-state Li-S batteries, such as eliminating dendrite formation during deep Li plating/stripping and achieving good utilization rates with high sulfur loading cathodes. They noted that the future studies are aimed at addressing these shortcomings and emphasized the need to demonstrate solid electrolyte in full cells with optimal sulfur host materials under practical, relevant conditions. However, they mentioned that while progress has been good and results are promising, it is unlikely that the technology can mature to the level of implementation within the project period. They recommended presenting a reasonable timeline and strategy to support these studies in meeting DOE performance goals.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer commented on the alignment of the project's goals and efforts with the VTO Battery R&D programmatic goals, emphasizing the project's focus on high-energy density all-solid-state cells that are compatible with Li metal and offer improved cyclability.

Reviewer 2:

The reviewer stated that the project is highly relevant to the overall goals of VTO programs and noted the synergistic relationship between the development of solid-state Li-S chemistry in this project and other Li-S projects.

Reviewer 3:

The reviewer expressed that the project's development of high ionic conductive and stable electrolytes for high-loading Li-S batteries enables all-SSBs with high energy density, thus supporting the overall VTO subprogram objectives.

Reviewer 4:

The reviewer highlighted that the project's focus on designing high-energy and low-cost all-solid-state Li-S batteries aligns well with VTO's goal of developing advanced batteries to meet the increasing demand in automotive applications. They mentioned that these batteries have the potential to address energy density, cost, safety, and supply chain risk concerns associated with existing LIBs.

Reviewer 5:

The reviewer affirmed that the project supports the overall DOE objectives by working on advanced Li-S cells with higher specific energy, lower cost, enhanced safety, and improved cycle life compared to LIBs. They pointed out that SSEs offer a viable solution for long-life Li-S batteries by addressing challenges related to polysulfide shuttles in liquid electrolytes. They considered the results obtained so far as promising, making the project relevant to the DOE VTO's battery program objectives and goals.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that the resources allocated to the project are sufficient to achieve the milestones and goals.

Reviewer 2:

The reviewer remarked that the resources and funding level are adequate to make good progress and did not identify any weaknesses in this regard.

Reviewer 3:

The reviewer expressed that there is sufficient resource to finish the project, including materials design, characterization, and multiscale modeling.

Reviewer 4:

The reviewer observed that the project has involved scientists from multiple institutions with complementary expertise and capabilities, which provides enough resources to accomplish the proposed work.

Reviewer 5:

The reviewer commented that the resources for the overall project seem to be commensurate with the scope and adequate to achieve the targeted milestones.

Presentation Number: BAT579
Presentation Title: Multifunctional Gradient Coatings for Scalable High-Energy Density Sulfide-Based Solid-State Batteries
Principal Investigator: Justin Connell (Argonne National Laboratory)

Presenter

Justin Connell, Argonne National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 25% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

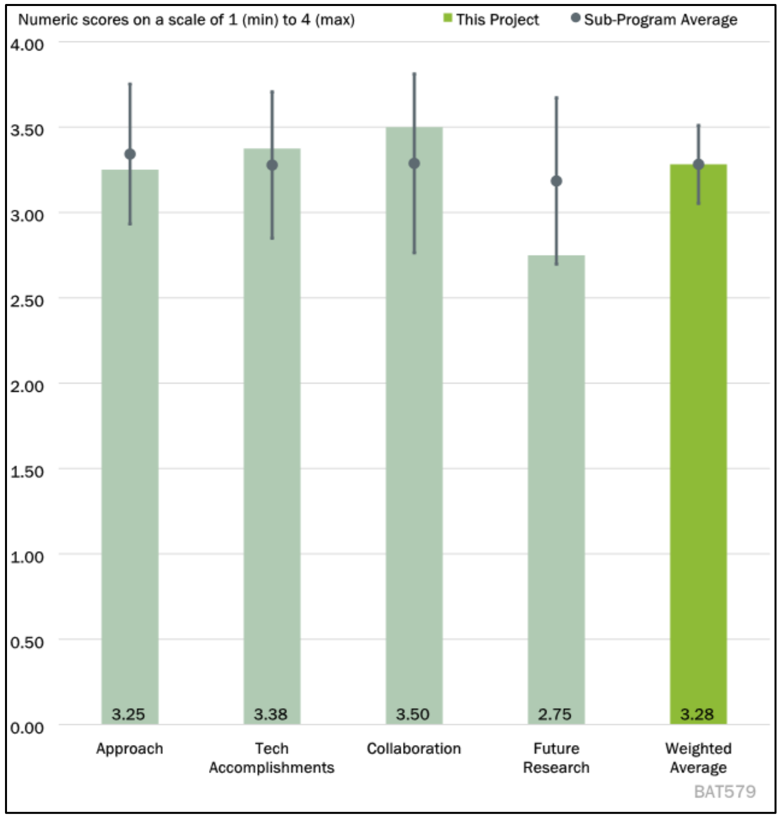

Figure 1-43 - Presentation Number: BAT579 Presentation Title: Multifunctional Gradient Coatings for Scalable High-Energy Density Sulfide-Based Solid-State Batteries Principal Investigator: Justin Connell (Argonne National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer mentioned that the approach involves purchasing commercially available argyrodite powders and coating them with a thin oxide layer, such as Al_2O_3. They raised concerns about the need for appropriate testing methods for components and cells using these coated powders, especially regarding densification, cycling at relevant rates and areal capacities, and components with relevant thicknesses. The reviewer pointed out that the approach slide, lacks quantitative testing methods for cell-relevant testing of the powders.

Reviewer 2:

The reviewer affirmed that the project aims to address concerns related to argyrodite stability with Li metal anodes and high voltage cathodes, as well as to improve air/moisture tolerance. They noted that the application of ALD coatings results in improved electrochemical and environmental stability of the ASE. The reviewer found the timeline and approach reasonable.

Reviewer 3:

The reviewer stated that the technical barrier of sulfide electrolyte stability to dry air is critical for practical applications of all-SSBs. They noted that the team improved the dry air stability of the Li_6PS_5Cl electrolyte by coating it with Al_2O_3, resulting in improved stability to Li metal compared to the uncoated version. However, the reviewer pointed out that the stability of Li_6PS_5Cl to Li metal is not fully addressed, as reduction of the electrolyte still occurs after Li plating, evidenced by the presence of reduction products (Li_2S and Li_3P) and an increased overpotential during Li plating/stripping cycles.

Reviewer 4:

The reviewer clarified that the project's approach involves making a sulfide-based electrolyte more stable by applying a thin coating of Al_2O_3 through ALD. They noted that the project used diagnostic tools to confirm the coating's presence, assess bulk chemistry changes, evaluate conductivity, and test the stability of a separator made from the coated electrolyte against Li and a cathode.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer expressed that relative to the project plan, technical progress appears good. They mentioned the availability of a publication that reports on the project's work and noted that goals related to moisture reactivity have been achieved. Additionally, the reviewer observed that some Li/Li cycling has been demonstrated.

Reviewer 2:

The reviewer deemed technical progress to be aligned with the project plan and timeline. The reviewer acknowledged that the team has made progress in understanding the role of ALD coatings in enhancing the stability of argyrodite electrolytes and has plans to further investigate how coated materials perform in electrochemical cells.

Reviewer 3:

The reviewer indicated that the technical progress meets the milestones set for the project. They detailed some of the findings, including the confirmation of the presence of the coating on the electrolyte surface through EDS analysis, the protective effect of the coating in dry and wet air, and the reduction in Li_2S formation when in contact with Li metal due to the Al_2O_3 coating. However, the reviewer expressed uncertainty regarding the improvement in intergranular contact with the coating and questioned why the IC increased without a clear explanation.

Reviewer 4:

The reviewer raised concerns about the thickness of the coatings, as it is not clear how the team plans to achieve thinner coatings without using a binder. They noted that no work has been performed in this regard. Nonetheless, the reviewer acknowledged that the project has demonstrated good cyclability between Li, the SSE, and Li.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer suggested that the role of Solid Power could be further described in the project. They mentioned that the project involves purchasing commercially available powders and indicated that Solid Power may be involved in coatings in the coming year. The reviewer sought clarification on whether Solid Power has had a role in the project to date. Additionally, the reviewer noted that collaborations within ANL appear to be strong.

Reviewer 2:

The reviewer acknowledged that collaborations and teamwork within the project are well-integrated, as evidenced by the combined experimental-computational publication and the use of major research facilities.

Reviewer 3:

Regarding collaborations, the reviewer mentioned that there is collaboration with ANL for materials synthesis and characterization, as well as cell assembling and testing. They expressed the view that no additional collaboration is needed at this stage.

Reviewer 4:

The reviewer noted that there was good collaboration within ANL but no collaborations with outside partners mentioned in the project. However, they did mention that there are plans to start working with Solid Power.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer emphasized the need for testing that is more relevant and specific to component or device performance to ensure that the coating and compatibility work done so far is not rendered irrelevant due to its impact on component and cell fabrication and performance. They suggested assessing factors such as areal capacity, current density, and stack pressure to provide a comprehensive understanding of the coatings' effects.

Reviewer 2:

Regarding future work, the reviewer stated that the proposed research aligns with the project's goals and is programmatically in line with VTO subprogram goals. They noted the importance of understanding reactivity and compatibility at the interphase region between the coating and electrolyte. Additionally, they mentioned the need for computational models to address band alignment and phase stability of potential SEI phases.

Reviewer 3:

The reviewer provided two specific points for consideration in future work:

They suggested that the team needs to provide a more detailed plan for designing new coating layers at the cathode/SSE interface, including principles for preselecting coating materials.

They recommended that a detailed plan be developed for the scale-up of the coated SSE for integration into roll-to-roll processing, taking into account the stability of the coating materials to solvents or binders used in the roll-to-roll process.

Reviewer 4:

The reviewer mentioned that the team plans to test cathode compatibility next, explore other coatings for the cathode, and consider how to make thinner separators in the future.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer expressed that the powders and processing techniques employed in the project are relevant to Battery program goals.

Reviewer 2:

The reviewer mentioned that the project supports VTO programmatic goals by focusing on enabling SSBs for use with Li metal anodes and high voltage cathodes through the design of interfacial coatings using ALD.

Reviewer 3:

The reviewer highlighted that this project developed a Li_6PS_5Cl electrolyte with improved stability to the Li metal anode, which facilitates the development of high-energy density Li-metal batteries. This development aligns with the VTO subprogram objectives.

Reviewer 4:

The reviewer noted that VTO is interested in advancing solid electrolyte batteries, and this project's demonstration of using ALD coatings on separator materials opens up a new avenue for researchers to explore in this field.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer expressed that the resources for the project appear sufficient for the current scope of work.

Reviewer 2:

The reviewer noted that additional resources might be required if the project were to seriously pursue component and cell fabrication and testing in the future.

Reviewer 3:

The reviewer mentioned that ANL has strong capabilities for materials synthesis and characterization, and the collaboration with Solid Power provides access to facilities for materials scale-up.

Reviewer 4:

The reviewer indicated that, based on the future work and progress achieved so far, it appears that the project has sufficient resources to meet its objectives.

Presentation Number: BAT580
Presentation Title: Thick Selenium-Sulfur Cathode Supported Ultra-thin Sulfide Electrolytes for High-Energy All-Solid-State Batteries
Principal Investigator: Guiliang Xu (Argonne National Laboratory)

Presenter

Guiliang Xu, Argonne National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

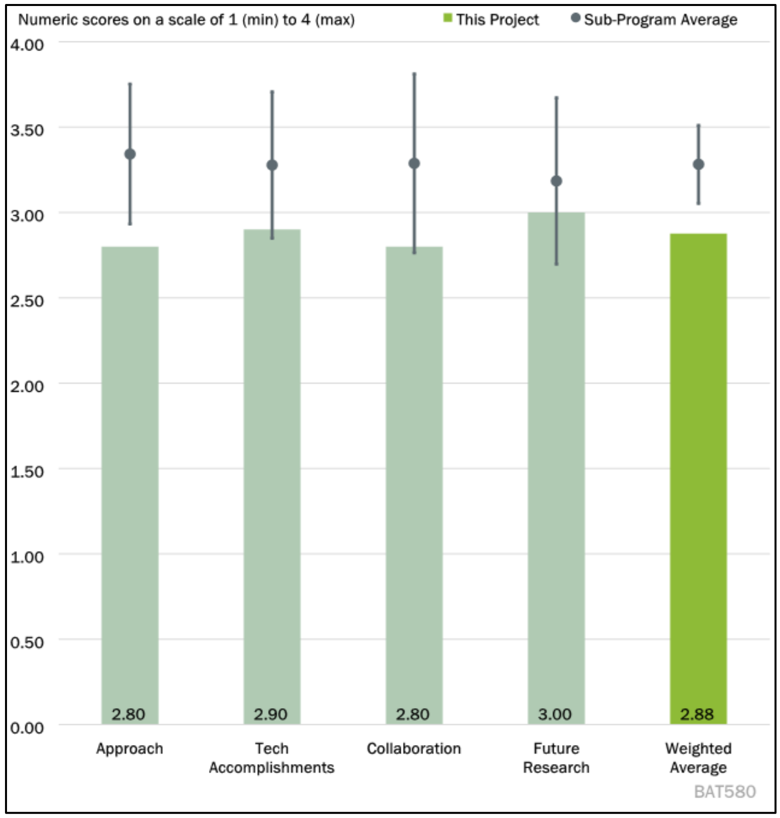

Figure 1-44 - Presentation Number: BAT580 Presentation Title: Thick Selenium-Sulfur Cathode Supported Ultra-thin Sulfide Electrolytes for High-Energy All-Solid-State Batteries Principal Investigator: Guiliang Xu (Argonne National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer found that the project was well-designed, and the timeline appeared to be reasonably planned.

Reviewer 2:

The reviewer observed that the presented approach aimed to incorporate oxygen into the sulfide argyrodite structure as a strategy to enhance the air/moisture stability of sulfides. The work conducted thus far seemed preliminary, with initial efforts primarily focused on building laboratory capabilities for electrolyte synthesis and *in situ* experiments. While the timeline for argyrodite synthesis and testing appeared reasonable, the reviewer expressed concerns about the ambitious nature of the timeline for optimizing the sulfur cathode structure/architecture (SCSA), given the project’s progress to date.

Reviewer 3:

The reviewer commented on the program’s progress in the synthesis of ASE. According to the reviewer, the program had generated few significant new insights or advances in this crowded research area. The highlight appeared to be grinding materials and heating them to follow crystallization using X-rays. This approach had been extensively utilized in the past, and the reviewer did not perceive the program as contributing significantly to this existing body of work. The reviewer also expressed expectations for the team, given the extensive resources available at DOE facilities, to deliver more substantial advances in comparison to simply grinding and heating materials.

Reviewer 4:

The reviewer recognized the project's focus not only on materials property improvements but also scale-up and performance enhancements, such as cycle life and fast charging.

Reviewer 5:

The reviewer made two key observations. First, they emphasized the importance of air stability for the dry-room synthesis of the sulfide solid electrolyte. However, IC is more important for the electrochemical performance of SSBs. The obtained IC (0.4 mS/cm) of the work was insufficient for a high-performance SSB. Second, the reviewer stressed the significance of stabilizing the Li solid electrolyte interface to attain a high critical current, which was deemed necessary for SSB with a thick SeS cathode.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer stated that the technical progress made so far aligns with the project plan.

Reviewer 2:

The reviewer remarked that the team has shown preliminary progress in synthesizing doped argyrodites and conducting initial measurements of IC and critical current density (CCD). Additionally, the team has developed *in situ* X-ray methods for assessing the impact of humidity on solid electrolyte stability. The reviewer emphasized the need for further research to comprehend the differences in degradation pathways resulting from oxygen substitution. They also raised a question regarding the extent of oxygen successfully incorporated in the doped argyrodite compared to the oxygen contamination present in commercial argyrodite.

Reviewer 3:

Commenting on the project's milestones, the reviewer noted that while accomplishments were evident, there was a noticeable absence of efforts to advance the technology beyond basic synthesis. Furthermore, the reviewer expressed concerns about the inadequate documentation of degradation studies, suggesting that these studies could have been conducted at various universities.

Reviewer 4:

The reviewer affirmed that the project had not adequately addressed the stresses imposed on the material during processing, along with strategies to mitigate issues such as grain boundary cracking or deformation. The reviewer underscored that if interfacial resistance remains unaddressed, functionality would significantly fall short of expectations. The reviewer highlighted the potential benefits of the new synchrotron setup in addressing moisture instability, a persistent challenge with these materials.

Reviewer 5:

The reviewer verified that the project had successfully synthesized the solid electrolyte $Li_6PS_{4.8}O_{0.2}Br$ and achieved similar room temperature IC and CCD as Li_6PS_5Cl from the vendor. However, the reviewer pointed out that air stability had improved but had not been completely prevented. The reviewer emphasized the insufficiency of the achieved low IC and CCD, stressing the need for further improvement to meet the requirements of high loading cathodes, which demand high currents for achieving a large energy density.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer affirmed that the collaboration within the project team is close and appropriate. They noted the presence of contributions from national laboratories and emphasized that there appeared to be no areas where additional collaboration was required.

Reviewer 2:

The project effectively leverages collaboration among synthetic, microscopy, and synchrotron X-ray experts. The preliminary technical achievements, according to the reviewer, indicate that the project team is effectively working together.

Reviewer 3:

The reviewer expressed a lack of extensive collaboration within the solid electrolyte program at DOE. They pointed out that, given the extensive work on argyrodites in the portfolio, the project appeared somewhat insular in its efforts. The reviewer also noted the absence of work at the National Synchrotron Light Source (NSLS) or ALS.

Reviewer 4:

The reviewer praised the collaboration across the team, indicating that it seemed to be in good shape.

Reviewer 5:

Regarding the project's illustration of collaboration with team members through assigned test works, the reviewer suggested that while the project does show these assignments, there is room for further improvement in terms of close coordination.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer affirmed that the project had clearly defined a purpose for future work and expressed confidence that the upcoming work was very likely to achieve its targets.

Reviewer 2:

The proposed future work was regarded as purposeful and in alignment with the programmatic goals of VTO Battery R&D, which aim to develop high energy density all-SSBs. However, the reviewer noted that, based on the preliminary work conducted thus far, there were concerns regarding the ambition of the future work focused on S cathode fabrication in FY 2023-Q4, especially since the technical accomplishments of those efforts were not presented.

Reviewer 3:

The reviewer stated the previous comments on the project served as the evaluation.

Reviewer 4:

The reviewer noted that the future plans outlined by the project included addressing S loading, a significant issue for optimizing the performance of S-based cathodes, as well as addressing the mechanical properties of the sulfide solid membranes. The approach to identifying solid-state Li-S failure mechanisms was viewed as potentially highly informative for guiding future work.

Reviewer 5:

Regarding the proposed future work, the reviewer noted that it addressed most of the requirements for current SSBs. They expressed optimism that Q4-2023, Q1-2024, and Q2-2024 were likely to be realized, as similar works had been reported. However, the reviewer cautioned that Q3-2024 and Q4-2024 could be more challenging due to the substantial uncertainty associated with the proposed strategies and approaches during those periods.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer affirmed that the project supports the overall VTO subprogram objectives.

Reviewer 2:

The technical goals outlined in the project, aimed at improving the stability and conductivity of ASEs and developing high sulfur (S) utilization cathodes, were seen as aligned with the programmatic goals of VTO Battery R&D.

Reviewer 3:

The reviewer noted that while solid electrolytes are undoubtedly an important topic area, the project team appeared to be lagging approximately three years behind their peers. The reviewer recommended better integration with other programs within DOE, including those within ANL.

Reviewer 4:

The reviewer emphasized that this effort was in line with VTO’s Advanced Battery Materials R&D efforts for next-generation batteries, further supporting the overall VTO subprogram objectives.

Reviewer 5:

The reviewer felt the project’s focus on solid electrolyte materials synthesis and analysis, along with its target of developing SSBs, is promising for energy storage systems related to electrification, advanced engine and fuel technologies, and energy-efficient mobility systems.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer affirmed that the resources available are sufficient for the project to achieve the stated milestones in a timely fashion.

Reviewer 2:

The reviewer felt resources for the program overall were adequate to accomplish the milestones. However, the reviewer did note that the shutdown of the APS could pose challenges for *in situ* X-ray scattering work. Nevertheless, the partnership with NSLS-II at BNL was expected to help mitigate these challenges.

Reviewer 3:

While acknowledging the value of using X-rays for tracking structural evolution, the reviewer expressed the view that there appeared to be more potential applications or avenues to explore beyond what was presented.

Reviewer 4:

Regarding the project’s stage of development, the reviewer indicated that, although it was in its early stages, the available resources appeared sufficient to complete the work as scoped.

Reviewer 5:

The reviewer pointed out that the project, hosted by ANL, benefited from having sufficient resources due to the laboratory's reputation for advanced characterization, testing, and simulation resources. Moreover, their partnerships with BNL and LBNL, both known for their strong backgrounds in relevant fields, further contributed to the project's resource adequacy.

Presentation Number: BAT581
Presentation Title: Precision Control of the Lithium Surface for Solid-State Batteries
Principal Investigator: Andrew Westover (Oak Ridge National Laboratory)

Presenter

Andrew Westover, Oak Ridge National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

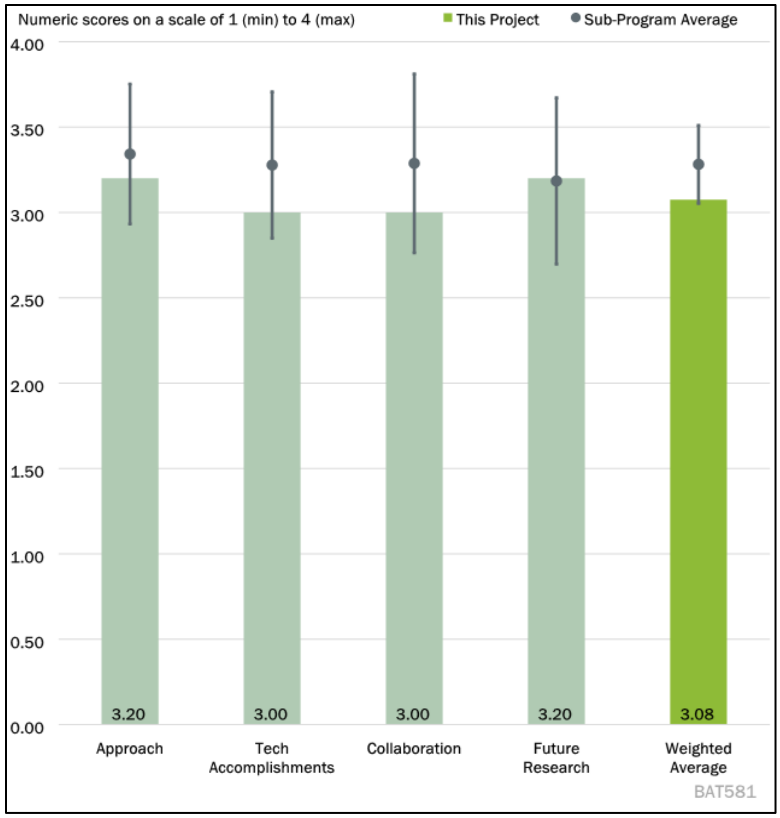

Figure 1-45 - Presentation Number: BAT581 Presentation Title: Precision Control of the Lithium Surface for Solid-State Batteries Principal Investigator: Andrew Westover (Oak Ridge National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer commented on the project’s approach to studying Li surfaces, noting that while it was reasonable, this topic had been previously investigated multiple times in the past. The reviewer also pointed out the complicating factor of the interpretation of results because a dirty Li surface can protect the cell from excessive Li loss.

Reviewer 2:

The reviewer praised the work as excellent and an interesting approach. They emphasized the potential for important scientific outcomes from the team’s efforts. However, the reviewer provided two critiques: First, they questioned the relevance of the study’s basis, considering that the main commercial path for a Li metal cell may not involve Li foil initially. Second, the reviewer suggested that more aggressive cycling conditions were needed to evaluate the impact of the Li source, as the proposed metrics were comparatively less aggressive and of limited relevance for eventual cells.

Reviewer 3:

The reviewer expressed enthusiasm for the project, considering it excellent and interesting. They highlighted the appropriateness of the ORNL team for conducting such research, citing clear experimental tasks and a well-defined timeline.

Reviewer 4:

The reviewer commended the PI's focus on the Li metal anode for SSBs, including understanding and engineering the Li metal surface. However, they raised two concerns: First, the apparent lack of attention to the cathode's importance for SSBs and its potential influence on the choice of solid electrolyte and crosstalk effects with the Li metal. Second, they expressed concerns about the use of In, Ag, Cu, and Au for Li metal surface treatment, especially given that Cu and Au are not generally miscible with Li. The potential reactivity of alcohols used for Li metal surface treatment was also noted.

Reviewer 5:

Regarding the investigation of surface properties of original Li metal from different sources, the reviewer recognized its importance for understanding the stability of the Li anode. They suggested comparing Li metal with the same thickness initially.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer expressed disappointment that the project discovered discrepancies in the advertised thickness of Li only relatively late in the work stream. They emphasized that Li thickness has a substantial impact on cycling, making this issue of significant concern.

Reviewer 2:

The reviewer commended the team for their excellent work. They noted that the team had successfully characterized the surface of several Li foils and evaluated cycling on various solid electrolytes. Additionally, the team was exploring how surface layers influenced fundamental properties, including mechanical behavior.

Reviewer 3:

The reviewer highlighted that the team had established baseline metrics for Li provided by different suppliers, which represented a positive initial step toward achieving their project goals. They also pointed out the importance of uniform pressure across samples, as cell pressure played a vital role in the project.

Reviewer 4:

The reviewer acknowledged the depth-profile XPS work conducted by the PI on Li anodes from various sources. They noted the findings that the Li metal surface was highly dependent on the source and that different Li sources exhibited different stress relief properties. The reviewer also mentioned that the PI concluded that surface chemistry did not appear to significantly affect the overall stress relief properties. The PI had also characterized Li stripping plating efficiency using various Li metal anodes, with results indicating high dependence on the Li source.

Reviewer 5:

The reviewer stated that the project had made good progress and anticipated that the team would continue to study the grain boundary effects of different Li metals.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer emphasized the critical importance of determining the impact of the surface films on cell performance, highlighting it as a crucial missing piece in the current understanding. They noted that this task could be challenging without collaboration with a high-quality cell manufacturer, which was currently lacking in the team.

Reviewer 2:

The reviewer mentioned the existence of a positive collaboration with Michigan Tech. Furthermore, it was mentioned that the Michigan Tech PI would potentially move to ORNL, which was viewed as a positive development for the collaboration.

Reviewer 3:

The reviewer acknowledged that the team had demonstrated adequate collaborations within their own team. However, they recommended expanding collaborations with other VTO performers, especially after completing the tasks for Year 2.

Reviewer 4:

The reviewer deemed the PI's collaborations within ORNL and with Michigan Technological University as a positive aspect of the project.

Reviewer 5:

The reviewer regarded the team as good, with coordinated efforts and good collaboration demonstrated.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer stressed the critical importance of determining the impact of surface films on cell performance, noting it as a significant missing piece in current knowledge. However, they also pointed out that this could be challenging without collaboration with a high-quality cell manufacturer, which was currently absent from the team.

Reviewer 2:

Regarding the proposed future work, the reviewer found it sensible, particularly the plan to go beyond existing commercial foils and engineer the surface. They acknowledged that cycling depended not only on the Li side but also on the electrolyte side, emphasizing the need for careful control in both areas. Additionally, the reviewer mentioned that several reviewers had suggested looking at electrochemically deposited Li as part of the scope, which appeared promising, although it might not be within the current scope.

Reviewer 3:

The reviewer commended the clearly defined nature of the proposed future research, highlighting its potential to be transformative.

Reviewer 4:

The reviewer felt the PI's proposal to study the microstructure, surface composition, and solid electrolyte-Li adhesion for future studies was a sensible direction. The reviewer also noted the proposal to develop a high-performance Li anode using the approaches suggested for the project.

Reviewer 5:

The reviewer found the proposed work to be reasonable and the future research directions to make sense.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer provided a somewhat weak affirmation, expressing doubt about the large impact of a surface film on long-term cycling given the significant movement of Li during cycling. They noted that while a film on Li could impact interfacial contact resistance, it was unclear how a very thin surface layer would affect the cycling process.

Reviewer 2:

The reviewer acknowledged that the work was focused on how the properties of Li metal could affect cycling, with a particular emphasis on the Li surface. They considered this relevant to the goals of the Battery program.

Reviewer 3:

The reviewer stated that the project was highly relevant to the overall goals of VTO programs, emphasizing the importance of Li metal as a crucial component. They also noted that the knowledge developed in this project could potentially benefit other projects if efforts were made to disseminate the knowledge in a timely manner.

Reviewer 4:

The reviewer recognized the project as a SSE project and indicated that it supported the broader VTO beyond Li-ion battery project portfolio.

Reviewer 5:

The reviewer stressed the importance of investigating the surface properties of Li metal foils, underscoring the project’s relevance to VTO objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented that the resources were “fine.”

Reviewer 2:

The reviewer found that the resources were well aligned with ORNL capabilities and appeared to be sufficient.

Reviewer 3:

The reviewer noted that the resources and funding level were adequate for making good progress, with the possibility of the team utilizing surface-sensitive characterization techniques available at synchrotron facilities, such as soft X-ray absorption spectroscopy (XAS) and grazing incidence X-ray diffraction (GIXRD).

Reviewer 4:

In the reviewer’s assessment, the resources were deemed sufficient for the project to achieve the stated milestones in a timely fashion.

Reviewer 5:

The reviewer observed that ORNL possessed all the necessary resources for the proposed work.

Presentation Number: BAT582
Presentation Title: Inorganic-Polymer Composite Electrolytes with Architecture Design for Lithium Metal Solid-State Batteries
Principal Investigator: Enyuan Hu (Brookhaven National Laboratory)

Presenter

Enyuan Hu, Brookhaven National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 25% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

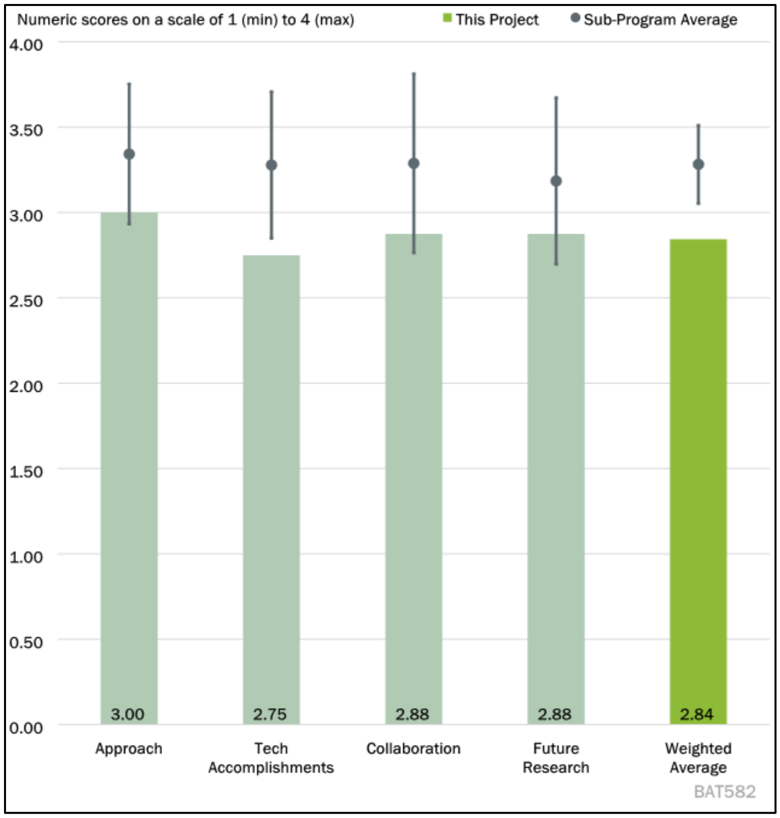

Figure 1-46 - Presentation Number: BAT582 Presentation Title: Inorganic-Polymer Composite Electrolytes with Architecture Design for Lithium Metal Solid-State Batteries Principal Investigator: Enyuan Hu (Brookhaven National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer assessed that the project plan was well designed to achieve the identified end goals.

Reviewer 2:

The reviewer recognized the merit of combining a polymer electrolyte with a stiffer sulfide electrolyte, considering it a promising approach. They also acknowledged that the investigators possessed the qualifications necessary to carry out this work. The reviewer noted the importance of improving conductivity in the polymer, especially in the context of composite systems. However, they suggested that some preliminary experimental work with the inorganic material would have been beneficial at this stage.

Reviewer 3:

The reviewer viewed the team’s aim to develop a practical SSB with a focus on a polymer and ceramic composite electrolyte positively. They noted that the team had adopted an excellent approach to address the issue, involving the design and synthesis of polymer materials with specific properties, design and synthesis of ceramic electrolyte materials, optimization of the composite electrolyte composition, and exploration of polymer electrolyte additives for Li metal anode and NMC cathode protection. The use of theoretical calculations, synchrotron, and cryogenic electron microscopy (EM) for characterization was also commended.

Reviewer 4:

The reviewer expressed concerns based on their attendance at a presentation, detailed analysis of presentation slides, and interactions during the presentation and subsequent quarterly reports. They indicated that the PIs did not appear to be aware of critical analysis techniques or synthetic strategies for developing true polymer networks or single-ion-conducting polymer electrolytes. There were concerns about the lack of details regarding the chemical compositions of the electrolytes and the inability to specify precise information during the question and answer session. The reviewer pointed out that the PIs seemed to understand the technical barriers in battery technology but lacked a clear understanding of how to develop and characterize materials effectively to overcome these barriers. Two specific instances of concern were highlighted: (1) the failure to quantify residual "sol" phase in the gel/network systems and the absence of quantification for residual solvents in PVDF or "single-ion" systems; and (2) the lack of specification regarding the chemistry of the putative single-ion system, making it uncertain if any ions were chemically bound to the polymer backbones. The reviewer found it difficult to assess the reasonableness of the timeline based on the broad and undefined "Approach" bullet points and the lack of well-justified strategies for creating new materials.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer evaluated the milestones for FY 2023 and noted that the progress, while not hitting the exact metrics identified, was satisfactory. They emphasized the importance of further work on process optimization to deliver high-performance materials.

Reviewer 2:

Regarding the two objectives listed for the period, the reviewer observed that there was generally good progress on developing the polymer electrolyte, but it was unclear if the goal of achieving "good mechanical strength" had been met. They noted the lack of clarity regarding whether the primary interest was the material's stiffness or its fracture resistance. For the second objective, the reviewer mentioned that work on the polymer/ceramic interface had not been presented.

Reviewer 3:

The reviewer acknowledged that the project had made a promising start and had achieved the defined milestone on time. The accomplishments included the optimization of the composition of a single-ion-conducting SPE to meet specific criteria, such as interfacial resistance, limiting current density, and membrane thickness under stacking pressure. Additionally, the team completed synchrotron-based characterization of a PVDF polymer-based solid electrolyte to assess its stability against Li metal and NMC cathode. Specific technical accomplishments highlighted by the reviewer included the successful fabrication of a PVDF-based polymer electrolyte using the solvent casting method and gaining an understanding of the degradation mechanism of SSBs using this electrolyte. It was noted that residual NMP solvent was found to be unstable against Li metal. The team also designed and synthesized a PUA-based polymer electrolyte using a solvent-free method. The reviewer mentioned the tuning of polymer electrolyte properties through adjustments in the degree of crosslinking in the polymers, with preliminary results indicating its suitability for cycling in NMC||Li SSBs. Furthermore, the team designed and synthesized a single-ion-conducting polymer electrolyte with specific characteristics, such as small thickness, high transference number, and a wide electrochemical window. The reviewer pointed out that a critical current density of 2.4 mA/cm^2 was achieved in SSBs using this polymer electrolyte. The team also obtained insights into how the coupling between Li cation hopping and anion movement influenced Li ion conduction in ceramic electrolyte. Additionally, possible strategies for improving IC in halide electrolytes were proposed. Overall, the reviewer considered these accomplishments as a positive reference point for major parts of the project, indicating a promising start to the research efforts.

Reviewer 4:

The reviewer pointed out several critical concerns regarding the project's approach to polymer-based electrolytes and the lack of essential information and characterizations. They noted that the PIs had pursued three drastically different strategies for polymer-based electrolytes, which required expertise in various areas of polymer electrolyte science. The reviewer suggested that a reduction in scope or a shift/increase in activity/manpower in this area might be warranted at this point. One major concern raised by the reviewer was the lack of detailed chemical compositions for any of the developed systems. They emphasized the necessity of characterizing critical parameters such as the amount of residual NMP solvent in the PVDF electrolyte and the mass fraction of residual monomers/liquid in the PUA system. These measurements, including solvent or monomer extraction and gravimetric quantification, were considered essential for assessing the suitability of these systems as solid electrolytes and understanding the components present, potentially including other solvents like water, and their effects on conduction and mechanical properties. Regarding the "single ion" system, the reviewer noted that there was insufficient information about how ions were attached to the polymer chain. They also pointed out the absence of details about the amount and nature of the solvent and/or small molecule content in this system. The reviewer expressed doubts about the accuracy of transference number measurements and emphasized the difficulty of conducting these measurements without large artifacts/errors. The reviewer highlighted the absence of mechanical or thermomechanical measurements, such as stress-strain, oscillatory shear rheology, and dynamic mechanical thermal analysis, on any of these systems. They stressed that these measurements were critical for understanding the nature of these materials for battery applications. Lastly, the reviewer noted that the computational/theoretical work had focused on ceramic conductors and had not addressed transport in the polymeric electrolytes generated or interfacial processes between ceramics and polymers in a composite electrolyte. They concluded that the lack of sufficient and appropriate information about the materials under study made it difficult to assess technical progress effectively.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer assessed the collaboration within the project team as "fairly collaborative" in delivering on the project objectives.

Reviewer 2:

The reviewer noted that the proposed contributions of different team members were well defined, and the collaboration on polymer electrolytes between Brookhaven and University of California Irvine appeared to be working well. However, the reviewer expressed concerns about the lack of discussion regarding collaboration with researchers working on sulfide electrolytes. They suggested that these interactions might become more relevant later in the project, but clarity on this matter was needed in the presentation. Additionally, the integration with modeling was not clearly explained, including plans for validation with experiments.

Reviewer 3:

The reviewer acknowledged that the PI had excellent partners for the project, including Prof. Huolin L. Xin from the University of California, Irvine, and Prof. Xin Li from Harvard University.

Reviewer 4:

The reviewer pointed out that while the PIs had substantially different expertise and experience, there was a lack of effective utilization of their skills in collaboration. Each PI had different capabilities, such as materials analysis, characterization, materials synthesis, computational/theoretical expertise, and battery assembly and testing expertise. It appeared that the PI making the presentation may not have had sufficient background to explain results from the other PIs, and there was a lack of close integration and collaboration among the PIs. The reviewer suggested that the range of topics studied by the team seemed widely disparate and not well-integrated, making it challenging to achieve effective collaboration.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer found the proposed research outline to be sound but lacking in detail. They noted that some targets, such as increasing the conductivity of the polymer electrolyte, were not clearly explained in terms of how they would be achieved. The reviewer suggested that further clarification about methods and approaches would be helpful to better understand the research plan.

Reviewer 2:

The reviewer found the overall direction of the future work to be well defined and logical. They pointed out that Slide 14 listed activities that were likely to be completed.

Reviewer 3:

Regarding the challenges and barriers identified by the PI, the reviewer noted that there were still challenges to address, such as further increasing the IC of the polymer electrolyte at room temperature, improving compatibility with NMC cathode and Li metal anode, and better understanding the interfacial properties between the polymer/ceramic electrolyte and electrodes. The proposed future research included decreasing the thickness of the PUA-based polymer electrolyte and improving its IC at room temperature, characterizing the compatibility between the single-ion conducting polymer electrolyte and NMC cathode, increasing the cathode loading in NMC||hierarchical ceramic electrolyte||Li cells to 8 mg/cm^2, and conducting synchrotron-based *in situ*/*ex situ* studies of the ceramic-based solid-state cells to understand the stability of electrode-electrolyte interphases.

Reviewer 4:

The reviewer reiterated their concern that achieving battery-relevant goals might be challenging without a more in-depth understanding of the materials through detailed characterization. They also noted that the proposed future research did not include the determination of basic properties of the electrolyte systems, which they believed should be a priority before pursuing further research.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer stated that the program supports the goals of the VTO subprograms.

Reviewer 2:

The reviewer stated improving solid electrolyte materials for the development of SSBs is critically important. The reviewer recognized the project’s focus on a promising approach and its high relevance to VTO program objectives.

Reviewer 3:

The reviewer mentioned that the project is concentrating on critical areas, including the design and synthesis of polymer materials with high IC and good mechanical strength, optimization of polymer fabrication methods to improve compatibility with electrodes, and gaining an understanding of the correlation between cation and anion movement coupling and Li conduction.

Reviewer 4:

The reviewer expressed concerns about the direction and work done so far in the project, suggesting that they may not be appropriate for achieving the program objectives. They referred to previous comments made in this regard.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that the resources are adequate for this project.

Reviewer 2:

The reviewer mentioned that the investigators have complementary expertise and appropriate resources to conduct the proposed work.

Reviewer 3:

The reviewer noted that the funding level is comparable to the scope of work, and the progress and findings are significant.

Reviewer 4:

The reviewer expressed concerns about the utilization of resources in collaboration. They mentioned that the different PIs have substantially different resources that complement each other, but it appears that these resources are not effectively used in collaboration. They specifically pointed out that synthetic abilities, materials analysis capabilities, and computational/theoretical resources may not be fully leveraged to achieve the project objectives.

Presentation Number: BAT583
Presentation Title: Development of All-Solid-State Battery Using Anti-Perovskite Electrolyte
Principal Investigator: Zonghai Chen (Argonne National Laboratory)

Presenter

Zonghai Chen, Argonne National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

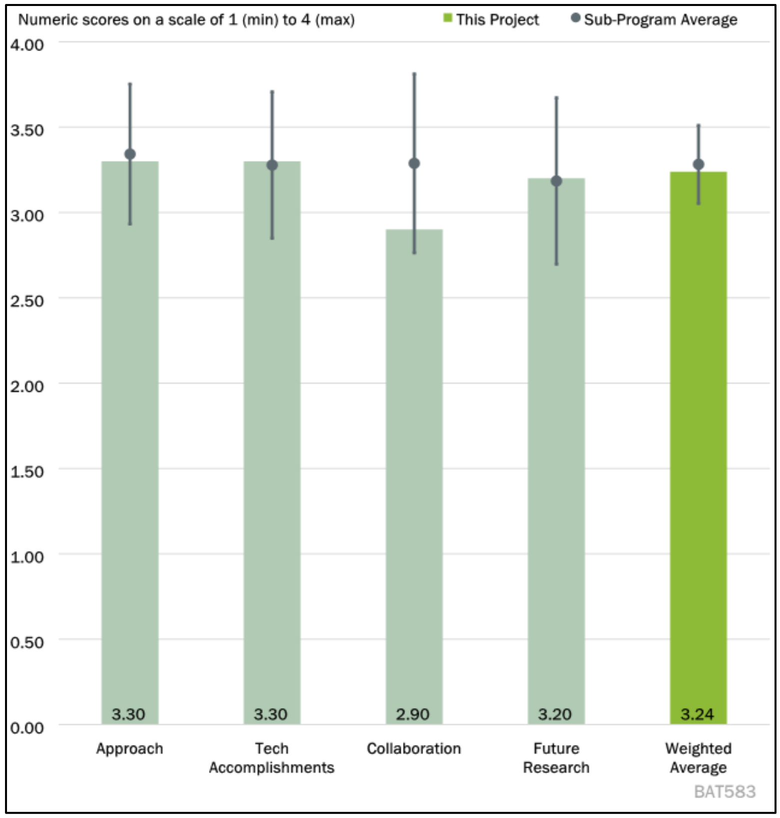

Figure 1-47 - Presentation Number: BAT583 Presentation Title: Development of All-Solid-State Battery Using Anti-Perovskite Electrolyte Principal Investigator: Zonghai Chen (Argonne National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer assessed the project's objectives, which included optimizing the synthesis of anti-perovskite solid-state electrolyte (AP-SSE), investigating the structure and interfacial stability, and exploring composite electrolytes to enhance Li-ion conductivity. The reviewer noted a suggestion to include a full cell test in the material development.

Reviewer 2:

In terms of project management, the reviewer found the proposed timeline to be reasonable. The team's achievements were acknowledged, particularly in materials synthesis, the chemistry of AP-SSE, understanding ion transport, and grasping the chemical and electrochemical degradation pathways. The reviewer observed that the project's primary focus so far had been on anion alloying/doping within the antiperovskite family, as outlined in the project's Approach.

Reviewer 3:

The reviewer expressed positive impressions of the program, highlighting the intriguing idea of utilizing AP-SSE and the importance of high-precision measurements. However, the reviewer also raised some concerns. They suggested that the research team should consider expanding collaborations, especially with other groups funded within the Battery Materials Research (BMR) program working on similar materials. The reviewer emphasized the potential of anti-perovskite materials as faster ion conductors when reacting with Li metal, suggesting that this valuable knowledge appeared underutilized in the current research approach. The reviewer also identified challenges related to electrode thickness and questioned the roles of the numerous project partners, suggesting that the involvement of 13 individuals might dilute the overall effort. Finally, the reviewer recommended that the program should establish more robust collaborations within the BMR portfolio, particularly with groups that seem to be further advanced in similar research.

Reviewer 4:

Regarding the technical aspects of the project, the reviewer highlighted the project's unique interfacial stability achieved through steady leakage current measurement. The use of antiperovskite materials as an ionic conductive binder to effectively bind lithium lanthanum titanate oxide (LLTO) was noted as an intriguing aspect of the research.

Reviewer 5:

In terms of the project's goals, the reviewer noted the ambition to develop a SSB with enhanced stability to Li metal and an NMC cathode. The reviewer summarized the project's approach, which involved starting with an AP-SSE, finding a low-cost method for synthesizing it, testing its stability using high-precision coulometry, exploring the substitution of different halides for improved stability, and ultimately finding a cost-effective method for preparing a separator with this material.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer remarked that significant progress had been made in material synthesis, interfacial electrochemical and chemical stability, which collectively contributed to a deeper understanding of AP-SSE. In contrast to liquid electrolytes, SSEs can exhibit electronic and IC, particularly in the case of semiconductors like anti-perovskite. It is suggested that the PI design an experiment to distinguish between these two types of conductivity.

Reviewer 2:

The reviewer observed that the project's approach encompassed electrolyte design, interface design, and process development. The reviewer noted significant strides in designing and synthesizing ASE and in the alloying of bromide/chloride analogs to fine-tune IC. Additionally, the team made progress in comprehending interface formation involving ASE, including their cycling stability with Li metal and stability when used in conjunction with LLZO as a composite electrolyte.

Reviewer 3:

Regarding the concept of a composite solid electrolyte, the reviewer expressed intrigue. However, the reviewer questioned whether there was a dearth of knowledge regarding the underlying mechanisms in this system, warranting reevaluation.

Reviewer 4:

The reviewer highlighted that the material synthesis process involved a solid-state method to produce anti-perovskite electrolytes, enhancing structural stability through doping with larger anions. Furthermore, the reviewer noted the development of a composite electrolyte to achieve high Li-ion conductivity at lower processing temperatures. The study investigated interfacial stability and identified an aggressive reaction between Al foil and anti-perovskite electrolytes, while confirming good chemical and electrochemical stability at the anode side.

Reviewer 5:

The reviewer stated that the research team had discovered a cost-effective method for preparing anti-perovskites and substituting boron for chlorine. The materials exhibited a melting point below 300°C. The reviewer noted that conductivity measurements at different temperatures revealed relatively low conductivity, approximately 0.01 mS/cm at room temperature. Subsequently, by mixing the material with LLZTO, a conductivity of 0.05 mS/cm at 25°C was achieved in a 40/60 AP/LLZTO blend. A thick separator (approximately 300 microns) was assembled and cycled between two Li electrodes at 0.1 mA/cm² for 1 mAh/cm², demonstrating over 250 cycles. The reviewer affirmed that a cathode composed of AP and NMC 622 was subjected to a voltage of 4.4V, and upon examination of the NMC surface after removal from the cell, a significant reduction of surface Ni was observed. This led the reviewer to suggest that AP may not be stable above 4.25V. In cell tests against Li metal, it was determined that Al was not stable against AP at 3.5V, whereas Ni and Ti exhibited stability at high voltages. Additionally, the reviewer commented that it was reported that AP exhibited instability in air at a relative humidity of 40%. Consequently, it appeared to the reviewer that the electrolyte demonstrated reasonable stability against Li-metal, although measurements of average CE through Li/Cu cells or limited Li/Li cells were not attempted. The reviewer, however, noted that the low conductivity and questionable stability against the cathode posed challenges to the viability of this electrolyte.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer noted that the PI has a long list of collaborators in universities and national laboratories, covering a wide area of expertise.

Reviewer 2:

The reviewer emphasized that while collaborative efforts are evident in the program's progress, it is essential to demonstrate how the team leverages this collective expertise and how these collaborations contribute to the presented progress.

Reviewer 3:

The reviewer expressed a desire for improved interaction with the other BMR programs, given the presence of 13 individuals listed as part of the project. The reviewer suggested that enhanced coordination and synergy with other programs would be beneficial.

Reviewer 4:

The reviewer acknowledged that the PI has successfully established numerous collaborations with universities and national laboratories, fostering strong partnerships in research and development.

Reviewer 5:

The reviewer pointed out that while several collaborators are listed at the end of the presentation, their specific contributions do not appear to be reported in the current context.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer commended the PI for having a clear plan for future work and expressed appreciation for the planned future full cell investigation.

Reviewer 2:

The reviewer also acknowledged that the proposed future research has a well-defined purpose and is aligned with programmatic and scientific goals. Furthermore, the reviewer found the future goals to be reasonable in scope.

Reviewer 3:

The reviewer expressed a desire for improved interaction with the other BMR programs, given the presence of 13 individuals listed as part of the project. The reviewer suggested that enhanced coordination and synergy with other programs would be beneficial.

Reviewer 4:

The reviewer highlighted that the proposed research efforts make sense. The reviewer noted that the team plans to map out the critical current density of their electrolyte vs stack pressure. However, there was some uncertainty regarding the team's direction in developing another electrolyte for the cathode and creating thinner separators, as the specific strategies were not clearly outlined.

Reviewer 5:

The reviewer observed that the team intends to build and test full cells with the available materials and investigate the source of failure. However, the reviewer expressed concern about the lack of clarity regarding the project's future trajectory and how it leads to improvement.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer affirmed that developing a structurally and chemically stable AP-SSE with the potential to lead to a long-cycle SSB aligns with the objectives of the VTO.

Reviewer 2:

The reviewer confirmed that the project goals are in support of the programmatic objectives of VTO, specifically concerning the development of all-SSBs with Li metal anodes.

Reviewer 3:

The reviewer expressed agreement with the significance of SSBs and suggested that improvements could be made in framing questions and enhancing collaboration within the team.

Reviewer 4:

While the project primarily focuses on the anti-perovskite electrolyte that is chemically compatible with metallic Li, the reviewer acknowledged that it remains a challenge to create functional full cells.

Reviewer 5:

The reviewer emphasized the importance of research into SSBs as a vital element within the DOE portfolio, considering it as another crucial piece of the broader puzzle in advancing energy storage technology.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer affirmed that the PI has sufficient resources to conduct the proposed research.

Reviewer 2:

The reviewer stated that the resources allocated for the project are deemed sufficient to attain the project's goals.

Reviewer 3:

The reviewer noted that the resources appeared to be sufficient.

Reviewer 4:

The reviewer expressed uncertainty about the project’s chemistry being a winning solution. Despite this uncertainty, the reviewer noted that there are adequate resources to follow this research path to its conclusion.

Presentation Number: BAT584
Presentation Title: Integrated Atomic-, Meso-, and Micro-Scale Diagnostics of Solid-State Batteries
Principal Investigator: William Chueh (Stanford University/SLAC National Accelerator Laboratory)

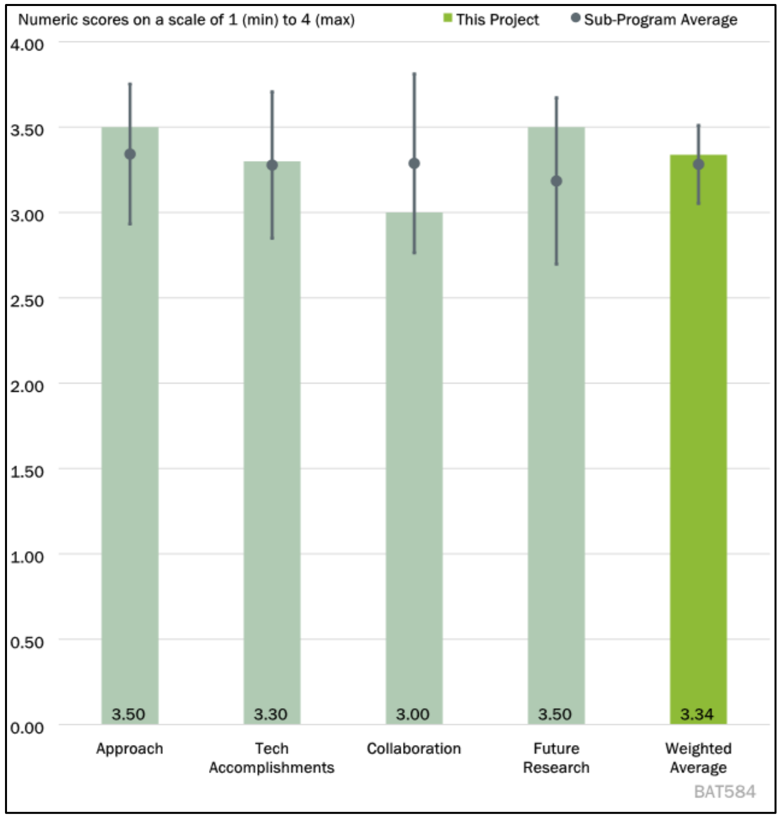

Figure 1-48 - Presentation Number: BAT584 Presentation Title: Integrated Atomic-, Meso-, and Micro-Scale Diagnostics of Solid-State Batteries Principal Investigator: William Chueh (Stanford University/SLAC National Accelerator Laboratory)

Presenter

William Chueh, Stanford University/SLAC National Accelerator Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 80% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 20% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer commented on the proposed material characterization approaches and *in situ* studies, stating that they are scientifically sound. They noted that many of the proposed approaches and tools are unique. However, the reviewer pointed out that while the PIs proposed using conducting atomic force microscopy to observe ionic and electronic transport at grain boundaries, no results on ionic and electronic transport were presented in the poster. Additionally, the reviewer expressed concerns that the proposed X-ray micro and diffraction tomography might lack the resolution needed to track solid electrolyte and Li microstructure evolution effectively.

Reviewer 2:

The reviewer acknowledged that the project effectively utilizes various surface science techniques to characterize interfaces in SSB, particularly focusing on Li plating in contact with LLZO electrolytes.

Reviewer 3:

The reviewer noted that the project had clearly outlined barriers and reasonably planned project milestones, demonstrating significant progress and results that contribute to the overall program. The approach involved the use of several microscopy methods to evaluate different aspects of the SSB, including microstructural changes, stress, and ionic transport.

Reviewer 4:

The reviewer highlighted the application of *in situ* EM to study the formation of Li dendrites with and without the presence of external pressure. They mentioned the observation of Li dendrite formation from remote areas during *in situ* experiments, leading to the conclusion that an electronic conducting path exists in garnet electrolyte pellets, promoting electron conduction to a remote area. The reviewer considered this technique novel and the conclusion significant for addressing the dendrite problem with mechanically strong electrolyte candidates. They also commended the strong support provided by the collected data. However, the reviewer suggested that developing techniques with larger detecting areas could complement this localized tool.

Reviewer 5:

The reviewer praised the excellent progress reported in the presentation and highlighted the importance of the characterizations in providing insight into processes at the Li metal to solid-state electrolyte (SSE) interface. While acknowledging the project's significance, the reviewer raised questions about whether the project alone could address the technical barriers to using Li metal and/or SSE in commercial batteries, given the broad scope of these technical challenges. Nonetheless, the detailed work described was considered a significant step in the right direction.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The research team employed *operando* SEM and cryo-TEM to characterize the nanoscale structure and short-circuiting in LLZO. It was noted that defects initiate Li intrusion, and higher mechanical loading increases the likelihood of intrusion, leading to intrusions at smaller Li-whisker diameters. Ultrathin metallic films were grown on LLZO to enhance defect tolerance and reduce the probability of Li intrusion and short-circuiting. However, characterization of these ultrathin film coatings was missing from the presentation, with the team planning to include them in future research. Additionally, the approach to growing the ultrathin film coating was unclear, and there was uncertainty regarding whether it had been reported in previous years. The size of the crack widths that trigger Li intrusion was not specified, and the reviewer suggested that characterization of the lithiophilicity of the LLZO material could be helpful.

Reviewer 2:

The reviewer noted that the experiments were well-designed to answer critical questions regarding the mechanical response of the solid electrolyte during plating. However, there was some uncertainty about how connections between the intrusion crack network and subsurface pores were established and how changes in porosity were determined. The type of defects that initiate intrusion was also raised as a question.

Reviewer 3:

The reviewer commended the authors for providing detailed results regarding the evaluation of solid electrolyte fracturing and Li plating. However, they noted that the effect of ultrathin metallic coatings on Li plating was described briefly, with silver and platinum showing the greatest benefit. The reviewer suggested that additional detail on some of the other milestones and accomplishments would have been beneficial.

Reviewer 4:

The reviewer appreciated the project team's commitment to developing novel characterization tools that could be valuable for other research teams. They recognized the clear research and development value demonstrated using garnet electrolytes as an example.

Reviewer 5:

Regarding the progress made in FY 2023, the reviewer noted significant achievements related to Q1-Q2 milestones concerning metal coating and visualizing their effect on Li metal intrusion and failure. However, there was uncertainty about the progress on Q3–Q4 milestones, as it was listed as “in progress” without specific details. The presentation primarily focused on nanoindentation and microscopy studies, which helped identify the probability of failure with and without thin metal coatings under various mechanical pressures and critical currents.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer acknowledged that the PIs already have excellent facilities and experience in material characterizations. They noted that the collaboration with LBNL-ALS is positive. However, the reviewer raised concerns about the absence of results from the X-ray microscopy experiments. The source of LLZO electrolytes was unclear, and the reviewer suggested that collaborations to fabricate and characterize LLZO would be helpful. Additionally, the reviewer found it unusual to list a student as a collaborator.

Reviewer 2:

The reviewer observed that no external collaborations were reported, which raised some concerns.

Reviewer 3:

The reviewer noted that the project team had a successful proposal to make use of facilities available at LBNL. They also mentioned that a student was shared on this project between both institutions.

Reviewer 4:

The reviewer recognized that the project team has a good collaboration with DOE-funded national user facilities for the project, and the accomplishments are beneficial to both the user facilities and the user community.

Reviewer 5:

In terms of teamwork and coordination, the reviewer found them to be fine. They noted that extensive use of national laboratory facilities requires coordination and commended the project for its effective collaboration among the team and external partners needed to conduct the work.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer found the proposed future research to be reasonable.

Reviewer 2:

The reviewer noted that the future plans are aligned with the proposed research.

Reviewer 3:

The reviewer stated the future work includes plans for additional characterization and optimization of the SSB. The reviewer considered the targets achievable and believed that they would increase the impact of the work.

Reviewer 4:

The reviewer mentioned that the project has a comprehensive forward-looking plan.

Reviewer 5:

The reviewer emphasized that, although briefly stated in the presentation, the work to be completed next, especially item #3, is likely the most strategically important to target. The reviewer explained that if the failure mechanism is defect-driven and will be limited by defect levels obtainable in manufacturing, it would be essential, before the project completes in FY 2024, to get an initial look at the level of defects in "typical" SSEs as manufactured. If the critical current is not inherently limited by the composition of the SSE but is instead limited by the level of defects, the focus should shift to that aspect.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer emphasized that this project is expected to generate valuable insights for engineering LLZO SSEs, and the success of this project will significantly benefit the development of advanced SSBs.

Reviewer 2:

The reviewer noted that the project is relevant to furthering the understanding of all-SSBs.

Reviewer 3:

The reviewer described the project's aim to design SSBs for use in EVs, which includes developing coatings for improved fast charging, enhancing safety by inhibiting short circuits, and engineering cell component compositions and surfaces to reduce degradation.

Reviewer 4:

The reviewer highlighted the importance of developing safe and high-energy-density Li batteries as a long-term strategy for DOE to electrify the transportation system. The execution of this project aligns well with the mission of DOE, and the knowledge and characterization tools obtained from this project would be valuable assets for the research and development community to rationally design high-performance SSBs for vehicle applications.

Reviewer 5:

The reviewer also pointed out the clear relevance of the work to the VTO objectives, particularly VTO's investment in Li metal anode. However, the reviewer cautioned against overselling the results and insights from the project thus far. While acknowledging the excellence of the work and its contribution to understanding SSE failure and suspected Li metal intrusion, the reviewer noted that claiming to have discovered the mechanisms may be premature. The presentation itself mentioned that finding Li metal penetration from surface intrusion to an inner pore had been "elusive." The reviewer acknowledged the importance of the data and observations, as well as the identification of suspects, but cautioned that the full story is not yet complete.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer noted that the PIs' teams have access to excellent facilities and unique research capabilities, indicating a positive aspect of the project.

Reviewer 2:

The reviewer stated that the resources were adequate.

Reviewer 3:

In terms of resources, the reviewer stated that the available resources appear sufficient to accomplish the project with their staff.

Reviewer 4:

The reviewer observed that the project team effectively utilizes DOE resources to accomplish the planned activities.

Reviewer 5:

The reviewer expressed no concerns about the resources, acknowledging that while additional resources might enable more extensive studies, results, and conclusions, the current level of investment appears appropriate for conducting the most important studies within the project.

Presentation Number: BAT585
Presentation Title: Anode-Free Lithium Batteries
Principal Investigator: Ji-Guang Zhang (Pacific Northwest National Laboratory)

Presenter

Ji-Guang Zhang, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

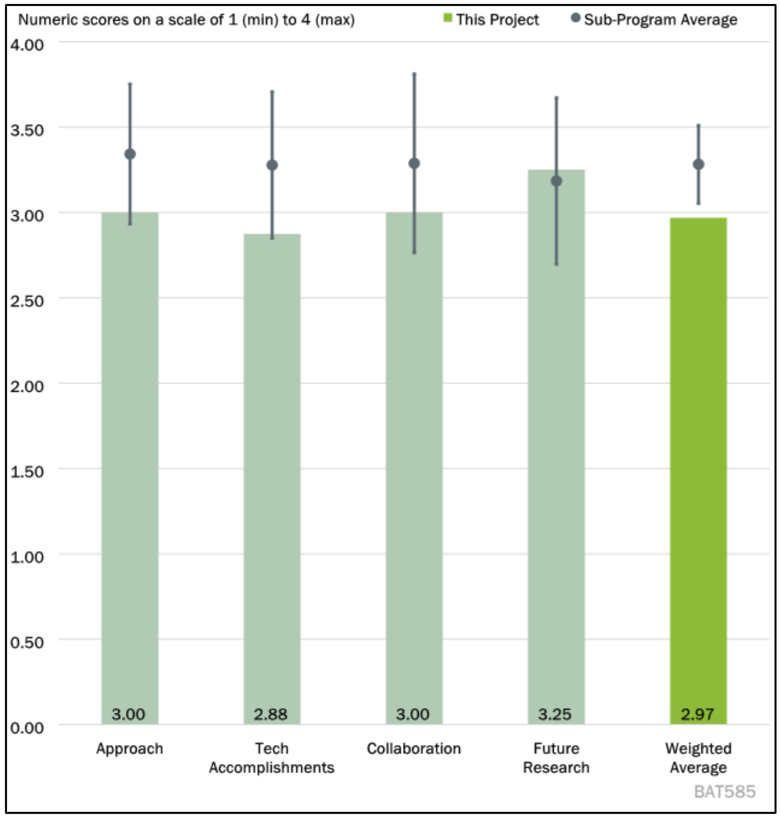

Figure 1-49 - Presentation Number: BAT585 Presentation Title: Anode-Free Lithium Batteries Principal Investigator: Ji-Guang Zhang (Pacific Northwest National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer cited the project's strategy for enabling high-energy-density batteries involves four key objectives: increasing CE to enhance cycle life; developing an artificial protection layer to improve Li utilization and CE; understanding SEI formation and dissolution; and enhancing safety characteristics.

The project primarily focuses on two main experimental approaches for achieving these improvements: electrolyte development and copper (Cu) substrate coatings. However, the reviewer raised concerns that while these approaches are typical, the results obtained so far do not indicate substantial improvements over the standard technical barriers observed in Li metal systems. Additionally, the reviewer noted that the approach and barriers for the SEI work were not discussed in the review. The reviewer highlighted ongoing challenges related to plating dense Li, including issues such as non-uniform Li deposition, dead Li, and short cycling life. Also noted was that pressure requirements remain a significant challenge for the program, and these challenges have been marginally addressed. The reviewer expressed uncertainty regarding the program's timeline, indicating a lack of clarity in this regard. Furthermore, the technical accomplishments mentioned in the review suggest that the technical barriers to improving cycle life and cell performance may not be fully addressed by increasing CE. The reviewer questioned why the Cu/Li system with a 99.7% CE exhibited the worst cycle life in the Cu/NMC cell. The reviewer pointed out that pressure is a known mechanism for improving cycle life and recommended that the project should place more emphasis on the proposed SEI work, which was not discussed in the review.

Reviewer 2:

The reviewer noted that the project aimed to address technical barriers associated with anode-free LIBs. The project's focus included the development of innovative localized high-concentration electrolyte formulations and gaining insights into the SEI formation and dissolution process. Additionally, the reviewer mentioned that the inclusion of tomography as a characterization technique could potentially enhance the project's approach, although it remained uncertain whether this technique was currently part of the project's scope.

Reviewer 3:

The reviewer emphasized that electrolyte development is crucial for achieving anode-free batteries. They commended the project for its well-designed approach, highlighting its potential to study the effects of electrolytes on SEI formation, thickness variation, and differences between coin cells and pouch cells. The reviewer noted that these investigations could yield critical insights into the feasibility of using localized high-concentration electrolytes for anode-free batteries.

Reviewer 4:

The reviewer found the review challenging due to several factors:

The four electrolytes, denoted as E1 to E4, were not chemically identified in the report.

The first approach mentioned, which is to "understand SEI formation and dissolution process and form SEI in the initial cycles," was not discussed in the report, making it unclear how this approach was implemented or what insights were gained from it.

In full cell testing on Slide 6, one of the electrolytes, E2, showed a significant failure after only 10 cycles, while the others exhibited similar cycling performance with approximately 60% to 70% retention after 100 cycles. The reviewer noted that the standard for cell cycling is to achieve 80% of the initial capacity after formation. Additionally, the cell with electrolyte E2 experienced severe shorting after about 20 cycles, which was not observed in the other cells. However, the report did not provide indications of what was learned from these tests regarding the effect of electrolytes on SEI formation, despite this being an important distinction among the electrolytes.

Subsequent testing in the report focused exclusively on electrolyte E1, but the basis for selecting this particular electrolyte was not provided.

On Slide 7, the report described the use of the E1 electrolyte with and without a polymer coating on the Cu substrate. While the initial cycles showed higher capacity with uncoated Cu, there appeared to be a slight advantage to the coated Cu cell during cycling. However, the difference was very small and possibly within experimental error, making it challenging to evaluate the test results.

The disappointing cycling results with the cells provided by LiFun indicated that the key variables for anode-free cells have not yet been identified.

Given these challenges, the reviewer recommended that the investigators broaden their evaluation of the electrolytes. This could include assessing factors such as conductivity (higher conductivity is preferable), viscosity (lower viscosity is preferable), projected cost (estimation is acceptable), safety (including considerations related to runaway reactions and environmental impact, such as the effect of high fluorine content), as well as cell performance metrics (rate capability, cycling capability, current handling, and energy efficiency).

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The technical progress in the project has yielded some valuable results, including the achievement of a CE milestone of 99.7%. The polymer coating on the Cu substrate showed a slight improvement, and there is a better understanding of the effects of pressure on the system. The successful cycling of multilayer pouch cells and encouraging safety performance in nail penetration tests were also noted as positive outcomes. However, the reviewer raised several concerns:

Technical results for two out of the three milestones required by December 2022 and March 2023 regarding SEI analysis and evaluation were not presented in the review.

While the CE efficiency milestone was technically met in a Cu/Li cell, it was observed that this cell had the worst cycle life in a Cu/NMC cell. This raised questions about the translation of high CE to improved cycling in an NMC cell.

It was not clear whether the cycle data for the polymer-coated anode and the multilayer stacked cells were obtained under pressure or ambient cycling conditions. However, the reviewer found the cycling and CE results for the Li-Fun cells encouraging.

The reviewer recommended addressing these technical weaknesses in future reviews to provide a more comprehensive assessment of the project's progress.

Reviewer 2:

The reviewer acknowledged the considerable progress achieved in developing localized high-concentration electrolytes. However, they suggested that further research might be needed to enhance charge/discharge CE. The findings related to pressure distribution in coin cells and pouch cells were deemed useful for addressing technical barriers in anode-free Li batteries (AFLBs). The nail penetration test demonstrated the safety of the studied AFLB; however, the reviewer questioned the link between this study and the project's overall goals. Lastly, it was noted that while coin cells with optimized pressure outperformed small pouch cells, it remained unclear how the ratio of cell components (e.g., electrolyte content) affected the comparison results.

Reviewer 3:

The reviewer expressed several concerns regarding the project's milestones for Dec. 2022 and Mar. 2023. These concerns include: (1) The milestones indicated a study on SEI formation and dissolution at different SOC levels as complete, but the presentation did not include any experimental results related to SOC dependence; and (2) The PI provided critical results comparing coin cells and pouch cells, which were not originally included in the milestones. Additionally, the reviewer expressed concerns about the lack of alignment between the cycling of full cells and anode half-cell cycling. They highlighted examples where the highest half-cell current efficiency did not correlate with successful full cell cycling. For instance, electrolyte E2 demonstrated the highest half-cell current efficiency but failed in full cell cycling beyond approximately 20 cycles. On the other hand, E1 had the lowest half-cell current efficiency but performed similarly to E3 and E4 in full cell cycling tests. E4 exhibited the best full cell cycling efficiency at the 100th cycle, reaching 74.5% of the initial capacity and the second-highest half-cell current efficiency.

Reviewer 4:

The reviewer recommended a shift in focus toward identifying critical variables that govern cycling on bare Cu and improving both half-cell and full-cell current efficiencies. They suggested exploring factors such as the smoothness of the Cu substrate's effect on initial Li growth, the nucleation energy of Li using the test electrolytes, and the impact of various types of Cu coatings, as these factors could have a significant influence on the cycling characteristics of Li metal.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer acknowledged the collaboration efforts within the project, specifically highlighting the collaboration with the EIC Laboratory for nail tests of pouch cells and with Binghamton University for thermal analysis of electrolytes.

Reviewer 2:

The reviewer noted that collaboration across team members appeared to be good.

Reviewer 3:

The reviewer mentioned that it would be beneficial to carry out the thermal analysis of electrolytes as suggested by Binghamton University to provide a more complete understanding of the capability of the electrolytes.

Reviewer 4:

The reviewer suggested that it would be beneficial to conduct thermal analysis of electrolytes, as recommended by Binghamton University. This analysis would contribute to a more comprehensive assessment of the capabilities of the electrolytes, providing valuable insights into their performance under different thermal conditions.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer expressed uncertainty about the potential success of the project’s future work based on the data presented in the review. They found it challenging to determine what new information the program had acquired about anode-free NMC architectures that would enhance cycling and safety performance in the future. The proposed future work included goals such as optimizing electrolyte composition to achieve a Li, CE greater than 99.8%, understanding SEI formation and dissolution mechanisms in the electrolyte, optimizing protection layers on Cu substrates, and improving electrolyte composition for enhanced safety in AFLBs.

Reviewer 2:

The reviewer noted that the approach to achieving these goals was not discussed in detail, and the proposed work seemed similar to what had been completed so far.

Reviewer 3:

The reviewer emphasized the importance of further developing electrolytes to achieve a CE greater than 99.8% and suggested conducting more careful comparisons between coin cells and pouch cells. They recommended using the same cathode material for both cell types to ensure consistent results, as the choice of cathode could significantly affect SEI formation.

Reviewer 4:

The reviewer pointed out the need to improve half-cell cycling efficiency, but they noted that the methodology for achieving this improvement was not addressed. They expressed concern that the key variables limiting the cycling of anode-free cells had not been identified and suggested that addressing this issue might require additional considerations beyond solvent and salt choice, such as the use of additives or treatments for the base

Cu substrate. The reviewer also questioned the reasons behind the notably worse performance of electrolyte E2 compared to others and sought further insights into this discrepancy.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer emphasized the significance of electrolyte development in the context of enabling high-energy density batteries and its relevance for advancing DOE goals in EV battery technology.

Reviewer 2:

The reviewer highlighted that the research on AFLBs contributes to increasing knowledge and can potentially lead to the development of high-energy batteries, aligning with DOE objectives in EV battery advancement.

Reviewer 3:

The reviewer underscored that electrolyte development is a critical factor in achieving high-energy density anode-free batteries.

Reviewer 4:

The reviewer noted that improving the cycling characteristics of such batteries could not only enhance cell capacity but also improve rate performance in Li metal batteries, making it an important area of research.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that the resources appear to be sufficient for the project.

Reviewer 2:

The reviewer mentioned that the funding for the existing project seems appropriate, but they suggested that more funding for the proposed future work may be necessary to employ additional characterization techniques for the study of the SEI.

Reviewer 3:

The reviewer noted that the resources are reasonably sufficient.

Reviewer 4:

The reviewer mentioned that the resources seem to be adequate.

Presentation Number: BAT586
Presentation Title: Earth-abundant Cathode Active Materials for Li-Ion Batteries: Cathode Design and Synthesis
Principal Investigator: Jason Croy (Argonne National Laboratory)

Presenter

Arturo Gutierrez, Argonne National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

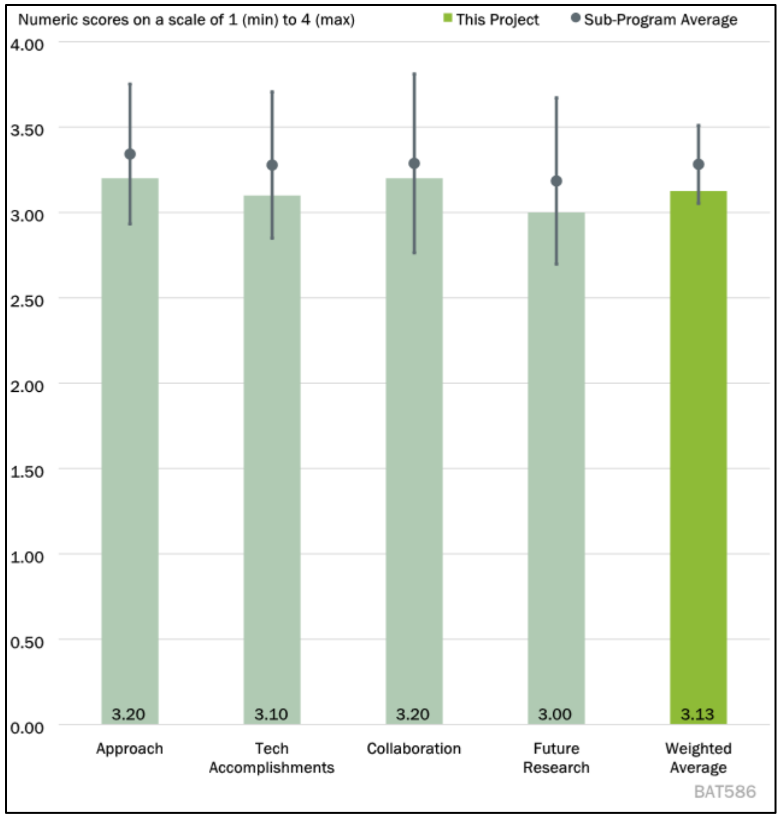

Figure 1-50 - Presentation Number: BAT586 Presentation Title: Earth-abundant Cathode Active Materials for Li-Ion Batteries: Cathode Design and Synthesis Principal Investigator: Jason Croy (Argonne National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer noted that the project appeared to be a scatter-shot effort to investigate how to dope manganese-based cathodes (Mn-based cathodes) to enhance their performance. They observed that no justification was provided for why Sn was chosen as a dopant.

Reviewer 2:

The reviewer expressed some confusion regarding the relationship between BAT586 and BAT569 and felt that further clarification would have been helpful. Overall, the reviewer commended the large, integrated nature of the program, which focused on low-Co and EaCAM and noted that it effectively leveraged numerous national laboratory capabilities. They also pointed out that the specific presentation focused on LMR materials, including dopants and precursors, and seemed to align well within the larger framework. The reviewer appreciated the integration of TEA as a positive aspect of the work.

Reviewer 3:

The reviewer considered it a sound approach to select manganese-based cathodes for the EaCAM due to the abundance of Mn compared to Ni or Co. They acknowledged that the team identified critical issues with Mn-based cathodes, such as voltage fade and Mn dissolution, and proposed a sound approach to address them. However, they suggested that it would be helpful for the team to clarify why Sn was chosen as a dopant to mitigate the Li/Mn migration issue in LMR. Additionally, given the numerous variables involved in optimizing the LMR (e.g., precursors, synthesis conditions, surface vs. structural modifications), the reviewer recommended the inclusion of a flowchart outlining their down-selection methodology.

Reviewer 4:

The reviewer pointed out that the stated program barriers included plug-in electric vehicle (PEV) battery cost, performance, safety, and Co content in relation to DOE goals and noted that the approach had the potential to overcome each barrier. They mentioned the absence of a provided plan timeline and explicit task outlines.

Reviewer 5:

In evaluating the project, the reviewer observed that it aimed to develop new strategies for high-energy, EaCAMs, particularly Mn-based materials. They noted that the project leveraged multi-year efforts on LMR cathodes and concluded that the project was well-designed. They found the approaches, which encompassed protocol development, composition optimization, synthesis/processing optimization, and modeling, to be reasonable and effective in achieving the project's goals.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer remarked that the team had collected a significant amount of data, but they noted a notable absence of effort to comprehend the data. Specifically, the reviewer questioned why Sn may accumulate at grain boundaries and pointed out that there was no attempt to elucidate whether this was advantageous or detrimental.

Reviewer 2:

The reviewer expressed praise for the technical accomplishments of the project. However, they commented that the presentation slides were densely packed with details, making it challenging to discern the specific achievements of this project over the past year. They also remarked that the summary slide seemed to focus more on the overall EaCAM program rather than providing a clear summary of this specific presentation.

Reviewer 3:

The reviewer affirmed that the team had done well in identifying the solubility limit of Sn dopant in LMR cathodes and its impact on structure and grain size. Nevertheless, they pointed out the notable gap of lacking electrochemical data to assess the effect of Sn dopant. They also commented positively on the investigation of the influence of the precursor (hydroxide vs. carbonate) on the first-cycle activation of LMR, considering it valuable information, especially at this stage when the project is only 15% complete.

Reviewer 4:

Stating that the technical progress achieved since the initiation of the program in October 2022 was impressive, the reviewer affirmed that it was accomplished in just six months. They praised the team's effective review, organization, and prioritization of a vast amount of background data based on program metrics. They also praised the initiation of studies on the use of Sn dopants to modify cathode material structure and the coordination of powerful and comprehensive techniques to investigate Sn solubility and phase structures. However, they pointed out that the modest actual performance improvements demonstrated so far were mitigated by the development of techniques that would facilitate expanded studies involving various chemical modifications.

Reviewer 5:

The reviewer began by noting that the project commenced on Oct. 1, 2022, and affirmed that the team had already generated promising results concerning the effects of Sn doping, grain size, and the choice of Li precursor for synthesis. However, they questioned whether more clarification could be provided regarding the precise impacts of Sn. They pointed out that PDF analysis revealed local structural evolution in the bulk, but TEM analysis indicated that Sn was primarily concentrated at grain boundaries. They questioned whether the effect of Sn was predominantly attributable to changes in the bulk or to the confinement of grain growth.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer acknowledged that there were numerous collaborators involved in the project but noted that the amount of data appeared relatively limited. However, they acknowledged that this limitation could be mitigated by the fact that the project had less than a year to work on it.

Reviewer 2:

The reviewer pointed out that the project involved a large team that leveraged many capabilities. However, they remarked that the specific collaborations for this particular work were not as clear.

Reviewer 3:

The reviewer commented that the team consisted of a good mix of national laboratories and academia. However, they stated that the specific contributions from each team member were not clear. They suggested that having an industrial partner could be helpful to guide the TEA.

Reviewer 4:

Regarding collaboration, the reviewer mentioned that about 80 highly capable team members and 12 major research facilities were involved in supporting the EaCAM programs. However, they noted that specific details on the collaboration were not included in the presentation.

Reviewer 5:

The reviewer highlighted the composition of the team, consisting of investigators from almost all national laboratories. Additionally, they commended the team’s efforts in supporting graduate students from more than half a dozen universities.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer questioned the basis for choosing future dopants, noting a lack of clarity on this matter. They observed that the remaining future goals appeared highly empirical, and they expressed a desire to see more effort put into systematizing what is learned from the research.

Reviewer 2:

The reviewer acknowledged that the proposed work was well-designed for cathode development. However, they commented that the placement of this project within the overall context of EaCAM was not entirely clear and suggested that this aspect could be improved for better contextualization.

Reviewer 3:

Commenting on the broad scope of future work proposed, the reviewer recommended the inclusion of a flow chart to illustrate a systematic and rational approach that would guide future efforts in addressing the critical issues.

Reviewer 4:

The reviewer noted the temptation to focus on sophisticated analysis techniques and their further development, as well as seeking deeper insights into existing materials and material classes. However, they emphasized that to overcome barriers, the development of new materials often requires exploring many variations of chemistry, potentially involving dozens of dopant combinations and synthetic variations. They suggested that while detailed physical characterization techniques can provide valuable insights, a greater focus on electrochemical performance might expedite the development of lower Co materials with higher energy density more directly and efficiently.

Reviewer 5:

Regarding the future plan, the reviewer found it reasonable but recommended a more systematic approach. They suggested that, given the numerous parameters involved, such as composition, crystal and local structure, and microstructure, it would be beneficial to reveal the precise effect of one parameter while keeping other parameters constant. Additionally, the reviewer encouraged the integration of more materials modeling work into the future work plan, noting that although it was listed in the milestones slide, it was not explicitly mentioned in the future work slide.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer affirmed that the endeavor to create superior cathodes was indeed relevant.

Reviewer 2:

The reviewer emphasized the high relevance of EaCAMs within the context of the Batteries program.

Reviewer 3:

The reviewer underscored the high relevance of the proposed Mn-based cathode, particularly in the context of ensuring a resilient battery supply chain.

Reviewer 4:

The reviewer noted that this project held significant relevance to the overarching objectives of the VTO subprogram. This included supporting the development of sustainable supply chains, advancing lower-cost materials, and addressing supply chain challenges associated with materials like Co. The reviewer also highlighted the importance of maintaining or enhancing energy density performance while focusing on full performance objectives related to power, life, and safety.

Reviewer 5:

The reviewer stressed the project’s importance in the development of low-Co cathodes with high energy density, aligning with critical objectives in battery technology.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said that the resources appeared to be sufficient.

Reviewer 2:

The reviewer stated that the resources appeared to be sufficient for this work.

Reviewer 3:

The reviewer remarked that the resources seemed sufficient, and this assessment was based on the FY 2023 budget.

Reviewer 4:

The reviewer expressed that excellent facilities and capabilities appeared to be in place to undertake this challenging program. They further noted that funding seemed to be adequate and not excessive.

Reviewer 5:

The reviewer concluded that the resources appeared sufficient for the proposed research.

Presentation Number: BAT588
Presentation Title: Earth-abundant Cathode Active Materials for Li-Ion Batteries: System Analysis
Principal Investigator: Daniel Abraham (Argonne National Laboratory)

Presenter

Daniel Abraham, Argonne National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

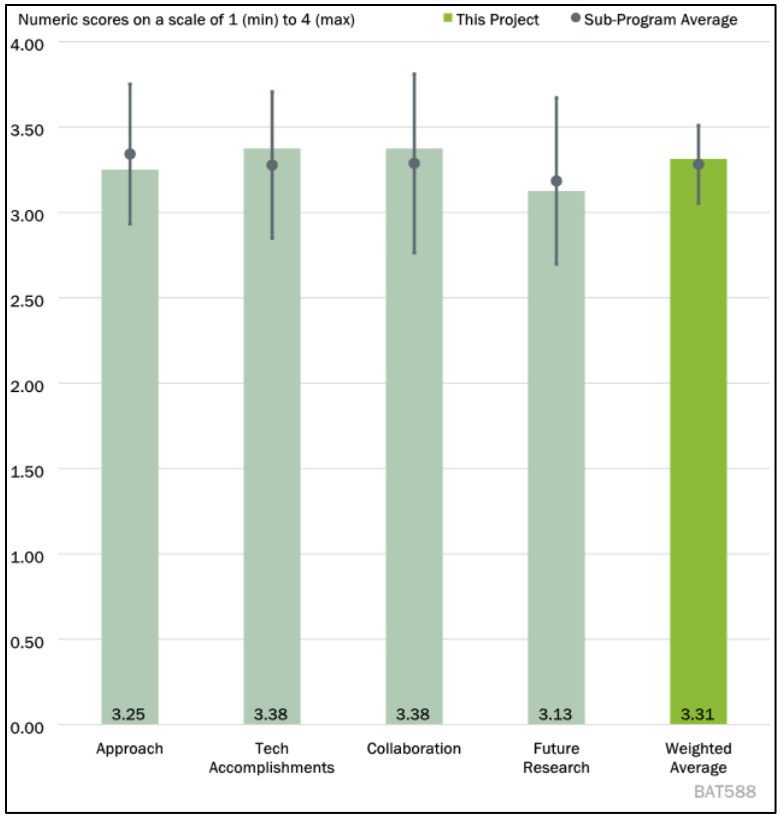

Figure 1-51 - Presentation Number: BAT588 Presentation Title: Earth-abundant Cathode Active Materials for Li-Ion Batteries: System Analysis Principal Investigator: Daniel Abraham (Argonne National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer outlined the two main objectives of the effort: (1) to develop and examine CAMs that are manganese-rich and obtain information on structure-property-performance relationships; and (2) to identify mechanisms associated with the performance loss (capacity fade, impedance rise, voltage fade) during extended cycling of these cathodes in cells containing anodes such as graphite. They noted that these objectives were an appropriate description of the intended work and effectively leveraged the strengths of the team. The reviewer also commented on the choice of target materials, $Li_{1.1}Mn_{0.55}Ni_{0.35}O_2$ (LMR-NM) and $LiNi_{0.5}Mn_{1.5}O_4$ (LNMO), and the extensive suite of characterization techniques deployed by the team to gain a deeper understanding of material and device performance.

Reviewer 2:

The reviewer found the approach to identify and solve the performance loss of EaCAM to be reasonable. They mentioned the application of a reference electrode and the challenge of electrolyte and additive selection, which may require trial and error. They suggested that theoretical understanding of the electrolyte and electrode interaction could provide valuable guidance for narrowing down electrolyte selections. The reviewer also questioned the need for evaluating LNMO/Graphite cells at 30°C and then 50°C, as the cell capacity fade and impedance rise mechanisms might differ between LMR-NM and LNMO CAMs.

Reviewer 3:

The reviewer highlighted the importance of systems analysis in the EaCAM project and emphasized the significance of measuring and modeling of anode surface interphase, degradation studies, and pouch cell studies with 3D imaging. They noted that standardized protocols were essential to evaluate the significance of the work appropriately and identify promising developments.

Reviewer 4:

The reviewer commended the project's design and timeline, noting that through rational cell design, the main technical issues for different cathode materials had been successfully discovered. They provided an example of how additives into Gen2 played a more important role in improving capacity retention for LMR-NM than coating on cathodes. Additionally, the reviewer highlighted the difference in capacity fading and cell resistance increase between LMR-NM and LNMO cathodes, attributing them to the graphite anodes.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer noted that despite this project being active for less than a year, substantial progress had been achieved in various directions by the research team. They acknowledged that the activities among different groups had been well-coordinated and focused, and progress had been distributed effectively across a wide range of materials and techniques, aligning with the project's stated goals. However, the reviewer pointed out an exception related to Li inventory tracking work, which pertained to different cathode and anode materials than the rest of the presented work.

Reviewer 2:

The reviewer highlighted that this was a relatively new project, commencing in October 2022, and mentioned that it had successfully completed its first milestone, remaining on track to meet other planned milestones.

Reviewer 3:

Several of the methods described were deemed important by the reviewer, indicating excellent progress. They acknowledged that while there was room for improvement in developing better cathode powders, the technical accomplishments in systems analysis were clear and valuable. The reviewer also encouraged the continued use of standard methods and cell builds.

Reviewer 4:

The reviewer commended the team for making good progress and identifying issues that affected the performance of full cells with different cathode materials. They praised the proposed approaches, such as coating and electrolyte optimization, and noted that these had been thoroughly compared and validated through advanced characterizations.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer expressed that the coordination within the team was impressive, especially considering the diversity of efforts represented. They noted that the research accomplished thus far appeared to have been carried out relatively independently within groups, and they identified opportunities to transition from mere coordination to a more highly collaborative approach as the project progresses.

Reviewer 2:

While the project included a comprehensive list of collaborators, the reviewer mentioned that the contributions from major collaborators and partners were not very clear from the presentation.

Reviewer 3:

The reviewer generally observed that collaboration appeared to be positive, albeit challenging to evaluate in such a large program.

Reviewer 4:

The reviewer described the collaboration within the consortium as good.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer commented that while the proposed future work seemed generally reasonable, it lacked specificity. They expressed the hope that clearer pathways to further improvements and focused efforts would have been identified at this stage in the project.

Reviewer 2:

Regarding diagnostic tests, the reviewer found them promising and emphasized the importance of electrochemical models that can illustrate interfacial transport and kinetic parameters. They also highlighted the need for eventual scale-up of the coating technique but noted that the team should focus on developing stable and high-performance coating materials before addressing scale-up. The absence of a clear plan for developing multi-component electrolytes with improved performance was noted, and the reviewer suggested that electrochemical models could be helpful in this regard.

Reviewer 3:

The reviewer stated that the proposed work appeared to align with program goals.

Reviewer 4:

In evaluating the proposed future work, the reviewer found it sensible, with some aspects being particularly vital. They emphasized the importance of evaluating cathodes with standard testing protocols, as it would benefit the larger team, and they also recognized the significance of *in situ operando* tools development to enhance the understanding of performance decay.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer emphasized the importance of developing EaCAMs with excellent electrochemical performance in batteries, noting that it was a central goal of the VTO Battery program.

Reviewer 2:

The reviewer stated that this project's focus on developing CAMs based on earth-abundant elements, such as manganese (Mn), was highly relevant to the EaCAM program's goal of discovering new strategies in materials design and synthesis using earth-abundant elements for the next generation of Li-ion cathodes.

Reviewer 3:

The reviewer found the work to be relevant to the Battery program goals.

Reviewer 4:

The reviewer found the work to be supportive of the VTO Battery subprogram objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer noted that extensive resources had been allocated to a range of national laboratory and academic partners and anticipated a high return on this level of investment.

Reviewer 2:

The reviewer observed that the project had a decent number of collaborators and access to key material research facilities. To maximize resource utilization, the reviewer suggested focusing on fundamental and theoretical studies of SEI formation and electrode-electrolyte instability mechanisms, rather than relying on trial and error when selecting electrolytes and additives.

Reviewer 3:

The reviewer stated that the program was large, and the resources appeared to be sufficient for its needs.

Reviewer 4:

The reviewer noted that the resources were deemed sufficient for achieving milestones in a timely manner.

Presentation Number: BAT589
Presentation Title: Cation-disordered Cathode Materials (DRX+) - Synthesis, Scale-up and Cell Testing
Principal Investigator: Guoying Chen (Lawrence Berkeley National Laboratory)

Presenter

Guoying Chen, Lawrence Berkeley National Laboratory

Reviewer Sample Size

A total of six reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

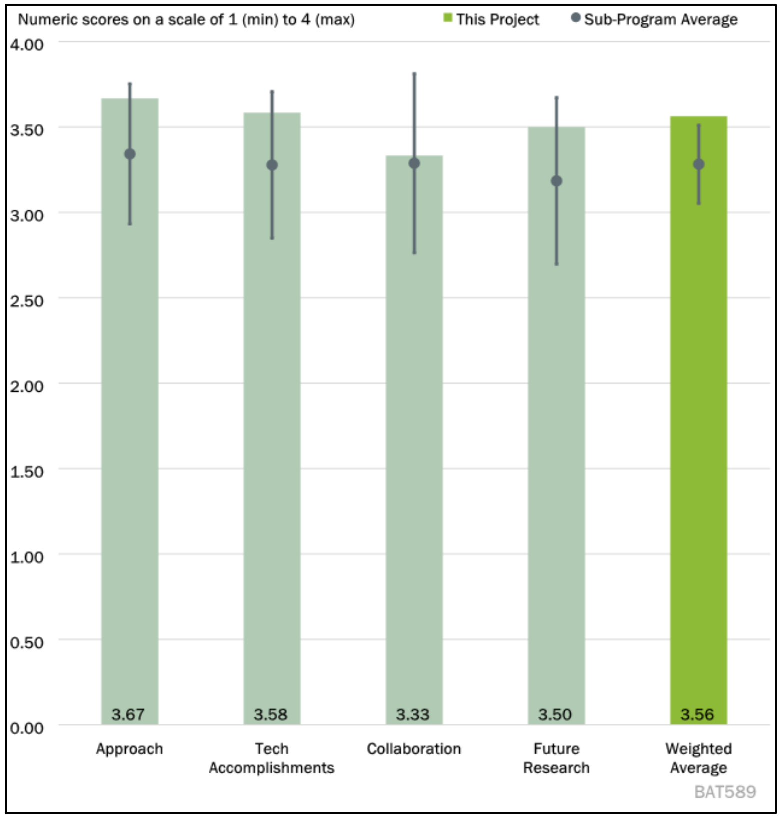

Figure 1-52 - Presentation Number: BAT589 Presentation Title: Cation-disordered Cathode Materials (DRX+) - Synthesis, Scale-up and Cell Testing Principal Investigator: Guoying Chen (Lawrence Berkeley National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer expressed some challenges in evaluating this portion of the DRX+ effort, as the approach described in the presentation seemed to be defined for the entire DRX+ effort rather than for this specific sub-team. They noted the importance of clearly defining the goals specific to this sub-team to facilitate evaluation.

Reviewer 2:

The reviewer acknowledged that the team had employed a combination of synthetic, electrochemical, and structural methods to gain enhanced control over DRX cell performance and understand the cycling-dependent changes in these materials. However, they suggested that while there had been a strong focus on understanding structural changes during electrochemical cycling, complementary efforts to use synthetic methods to control the domain structure and structural changes could be more impactful. The reviewer also raised the possibility of post-synthesis annealing and *in situ* annealing studies to tune phases and domain size for improved electrochemical performance.

Reviewer 3:

The reviewer found the project well-designed with a reasonable timeline and noted that it focused on high-Mn cathode development, which showed promise for high energy density and low cost. However, they indicated that it was still too early to comment on its life since the project had started only 8 months ago, and the material development was in its early stages. The reviewer also suggested demonstrating the total energy above 2.5V for practical applications.

Reviewer 4:

The reviewer outlined the five approaches presented in the project: fine-tuning synthesis conditions, developing conformal coatings, optimizing electrolyte formulation, optimizing electrode fabrication processes, and investigating partially disordered Mn-based high-energy cathode materials. They found the project well-designed with a reasonably planned timeline, aligning with the goal of developing high-capacity cathodes to enhance the energy density of LIBS.

Reviewer 5:

Regarding the continued effort of DRX with the aim to develop cation-disordered Li-excess rock salt cathodes free of Ni and Co, the reviewer commended the combination of computational and experimental work. They expressed satisfaction with the team’s focus on coating, electrolyte optimization, and synthesis/process optimization to promote practical applications of these cathodes.

Reviewer 6:

The reviewer noted that the program had just started, and their judgment was based on the proposed work, suggesting a positive path forward. They found the project well-designed, with a reasonably planned timeline, focused on understanding the relationships among performance, composition, and structure of DRX cathodes through advanced characterizations and adjusted testing protocols.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer recognized the team’s substantial progress in various project goals, which included scale-up, alternate synthesis methods, identification of structural phase transition signatures, correlation of structure with performance, and the establishment of a high baseline performance floor.

Reviewer 2:

The reviewer commented on the excellent accomplishments in materials synthesis and characterizations within the first 8 months of the project. The reviewer also noted the importance of planned performance tests in full cells to understand side effects on the cathode surface at high charge voltages, particularly because the discharge capacity over cycling in half cells using Li metal as anode may not reflect this type of Li loss.

Reviewer 3:

The reviewer summarized the project’s achievements, which included developing a Gen-1 DRX High-Mn class cathode with Mn content up to 0.8, demonstrating high voltage stability, observing anomalous capacity increases and cell impedance decreases, correlating capacity increase with local structural transformation via Li nuclear magnetic resonance spectroscopy (^{7}Li NMR), determining the key role of Mn content in structural properties, and demonstrating scale-up synthesis of GRX Gen-1. The reviewer noted that these accomplishments were particularly impressive given the short timeframe since the project’s inception in October 2022.

Reviewer 4:

The reviewer raised questions about the implication for cell balancing negative-to-positive (N/P) ratio if the cathode’s capacity continued to increase with cycles and inquired about planned efforts to manage this activation process.

Reviewer 5:

The reviewer noted the team's prolific publication record and the abundant increase in understanding based on these publications.

Reviewer 6:

The reviewer appreciated the team's deep understanding of High-Mn DRX cathodes regarding phase transformation and electrochemical behavior. The reviewer highlighted the significance of this understanding for future materials optimization and performance improvement. Additionally, the reviewer commended the team for achieving the scaling-up of cathodes (60 g/batch), which would benefit other partners and facilitate cathode development.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer pointed out that this project had a large team with a complementary set of skills. However, the reviewer noted that examples of strong collaborations and synergy between team members had not yet been demonstrated, both within this subtask and across the entire DRX+ team.

Reviewer 2:

The reviewer acknowledged that there were sufficient internal and external collaborations with national laboratories and universities but strongly recommended more collaborations with cathode materials suppliers and battery manufacturers. The reviewer also highlighted the potential benefits of the planned collaboration with ANL for scaling up.

Reviewer 3:

The reviewer noted that the impact of LBNL and ANL on the project was well-documented. However, the reviewer found it unclear what role PNNL, ORNL, SLAC National Accelerator Laboratory, and UC Santa Barbara had in the project or their accomplishments. The reviewer mentioned that collaboration and coordination could only be assessed based on the overall technical progress made.

Reviewer 4:

The reviewer considered the team, which involved five national laboratories and one university, to be excellent for this part of the project.

Reviewer 5:

Regarding collaboration, the reviewer mentioned that a standard sample had been shared among the team but found it challenging to judge at this early stage of the program.

Reviewer 6:

The reviewer highlighted the importance of scaling up high-quality DRX cathode powders and the development of new approaches to synthesize cathodes, which could benefit other partners in the consortium. The reviewer also noted that suggestions from industries for scaling up were always helpful.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer remarked that at this early stage, the future goals of the project align with the overall project goals. They noted that the identified needs for DRX improvement were clearly relevant to developing a pathway towards industrial relevance. However, the reviewer pointed out that it was not yet clear whether viable pathways to these goals existed, though this would likely become clearer as the project progressed beyond its initial stage.

Reviewer 2:

The reviewer expressed that the plan for scaling-up was well-constructed, emphasizing the importance of evaluating the high-Mn cathode in larger full cells for practical applications.

Reviewer 3:

The reviewer commented on the project's outline of five proposed future work items:

Further understand the behavior of high-Mn DRX to better utilize their potential as high-energy and high-rate cathode materials.

Improve DRC Gen-1 performance through materials optimization, including composition refinement, structure, and morphology tuning.

Develop new scalable synthesis routes for large-scale powder production.

Optimize composite cathode formulation to reduce carbon content and improve performance.

Develop testing protocols to maximize DRX performance.

Reviewer 4:

The reviewer noted that the project had clearly defined the purpose of future work and expressed confidence that the future work was likely to achieve its targets.

Reviewer 5:

The reviewer stated that the plan for future work appeared reasonable. They also suggested that, given this is DRX-2, it would be beneficial if the developed CAMs could be tested beyond coin cells by leveraging large cell fabrication facilities at national laboratories.

Reviewer 6:

The reviewer affirmed that the proposed future work made sense and that there was a high possibility that the targets could be reached as expected in the plan.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer acknowledged that the DRX system had the potential to meet some important goals of the batteries program, including achieving very high energy densities and developing battery systems using earth-abundant materials exclusively or nearly exclusively. However, they pointed out that this potential was tempered by the uncertainty regarding whether the very large impedances of these systems could be effectively mitigated. The reviewer noted that the sooner and more effectively this mitigation could be achieved, the clearer the need for further investment and development of this system would become.

Reviewer 2:

The reviewer affirmed that the project supported the overall VTO subprogram objectives, particularly in the development of high-energy and low-cost alternative cathodes, especially for EV applications.

Reviewer 3:

The reviewer expressed agreement that the project supported the overall VTO subprogram objectives. They emphasized the project's relevance in achieving high-capacity cathodes with a high Mn content (High-Mn content DRX-cathodes), which had been a bottleneck in high-energy density LIBs.

Reviewer 4:

The reviewer stated that the project would improve energy density and reduce the cost of today's Li-ion batteries.

Reviewer 5:

The reviewer highlighted that this approach represented one of the few ways to develop a high-energy storage cathode that could exceed the energy storage capability of high-Ni NMC cathodes.

Reviewer 6:

The reviewer concluded by affirming that this project fully supported VTO Battery subprogram objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that very substantial resources were devoted to this project.

Reviewer 2:

The reviewer affirmed that the resources were sufficient. They suggested that it might be more helpful to have industrial partners in addition to ANL to scale up to kilogram levels.

Reviewer 3:

The reviewer expressed agreement that the resources for this project were sufficient to achieve the stated milestones in a timely fashion.

Reviewer 4:

The reviewer commented that the resources looked reasonable.

Reviewer 5:

The reviewer noted that the resources for the entire program were sufficient for the fundamental work of this effort.

Reviewer 6:

The reviewer concluded that the resources were sufficient for the milestones to be achieved on time.

Presentation Number: BAT592
Presentation Title: Advanced Anode Manufacturing Through Ultra Thin Li Deposition
Principal Investigator: Subramanya Herle (Applied Materials, Inc.)

Presenter

Subramanya Herle, Applied Materials, Inc.

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

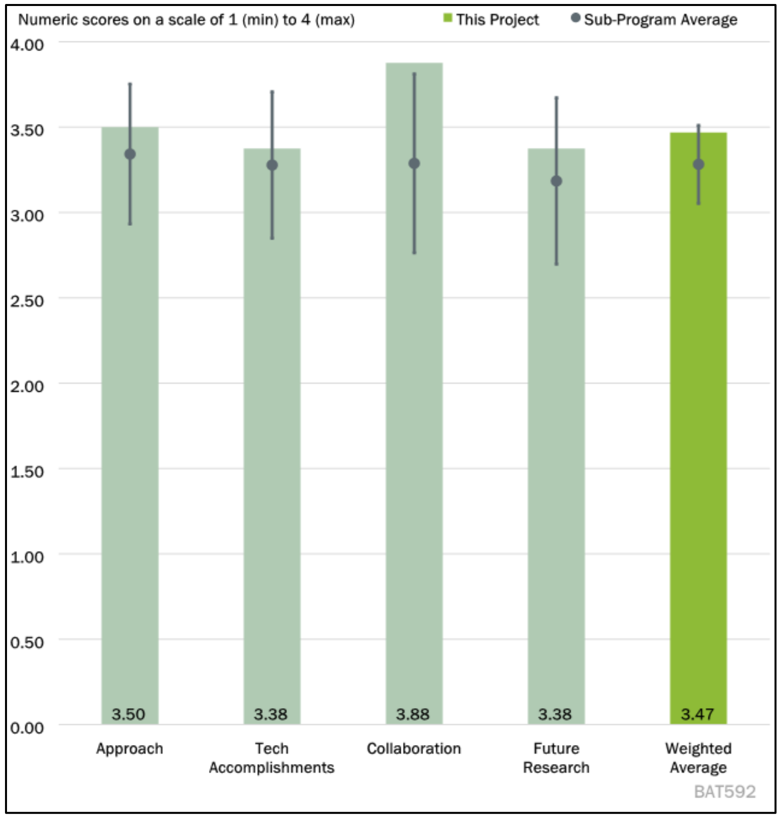

Figure 1-53 - Presentation Number: BAT592 Presentation Title: Advanced Anode Manufacturing Through Ultra Thin Li Deposition Principal Investigator: Subramanya Herle (Applied Materials, Inc.)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer stated that the main technical barrier was clearly stated in terms of addressing high-volume manufacturing (HVM) of high-energy density anodes for Li-ion/metal batteries.

Reviewer 2:

The reviewer commented that the technical approach was well laid out, specifically mentioning the use of a roll-to-roll Li-deposition approach to enable pre-lithiation of SiO_x-C anodes and the fabrication of ultra-thin Li-metal anodes. They also noted the strong partnership with industries and national laboratories for performance validation and techno-economic evaluation, with clearly defined targets (energy density, cycling life, cost), which was crucial for demonstrating the final project deliverables. The reviewer acknowledged that this was a challenging project but highlighted the expertise of the assembled team and their significant progress in the past two budget periods. They mentioned that although there had been some delay, all the milestones were scheduled to be delivered.

Reviewer 3:

The reviewer described the project's aim to provide high-volume manufacturing capability for roll-to-roll Li-metal deposition, for pre-lithiation of SiO_x-C anodes, and Li-metal anodes. They noted that the major tasks were mainly completed with a commercial SmartWeb™ platform but expressed some uncertainty regarding the technical barriers addressed to acquire this capability. The reviewer mentioned that the project provided Li-metal deposition and surface coating services to collaboration partners for pouch cell fabrication and testing.

Reviewer 4:

The reviewer explained that the investigators were developing lithiation processes for Li deposition and pre-lithiation of SiO_x to increase the energy density of these systems while aiming not to negatively impact cycle life. They noted the plan to develop high-rate processes that added little cost to manufacturing to make the overall battery cheaper. The reviewer observed that the team appeared to be making progress on multiple fronts and considered the project well-designed, having addressed its technical barriers effectively.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer praised the significant progress made in demonstrating roll-to-roll Li deposition for high-volume manufacturing (HVM), particularly for pre-lithiation of SiO_x-C anodes and the fabrication of ultra-thin Li-metal anodes. They noted that the targeted performance for budget period (BP) 2 had been achieved, and good progress was being made towards achieving the target performance for BP3. The reviewer commended the PIs/reporters for their presentation of electrochemical performance, stating that they had done fantastic work by including all technical details, clearly defined experimental procedures, and measurement parameters. However, they suggested that in the final report, the PIs may want to clarify how the N/P ratio of 0.5:1 was defined (Slide 13). Additionally, the reviewer mentioned that it might be necessary to provide clarification on the very high specific capacity, up to 200 mAh/g, reported for the NMC622/Li cell within the limited voltage range of 2.7V–4.4V (Slide 25).

Reviewer 2:

The accomplishments of the project were detailed, including the fabrication of pre-lithiated SiO_x anodes used in the R&D cells of Ionblox and the delivery of Li-metal anodes to SAFT America for 10 Ah pouch cells. The reviewer noted that in the comparison test, the cell with the pre-lithiated SiO_x anode and the SiO_x cell without pre-lithiation had similar performance, with the pre-lithiated SiO_x anode delivering slightly less capacity and poorer retention at the end of 900 cycles. They mentioned that the benefits of the ultra-thin Li deposition were not shown in the test. The reviewer also highlighted the accomplishment of the 300 Wh/kg pouch cell with NMC622 cathode and 10 um Li anode, which met the targeted 70% retention after 300 cycles. They noted that the purpose of the pre-lithiation procedure was to compensate for the first-cycle Li loss in the SiO_x anode, but this effect was not demonstrated in the report.

Reviewer 3:

The reviewer provided additional information about the performance of cells with pre-lithiated SiO_x built with IonBlox and Li-metal/NMC cells built with Saft America. They mentioned energy densities, cycle numbers, and capacity retention percentages for these cells. However, they raised a concern about whether the cells utilizing a small initial amount of Li metal would eventually succumb to catastrophic failure once the Li ran out.

Reviewer 4:

The reviewer acknowledged that the team had discovered some opportunities to evaluate alternative methods, which had led to a pivot in the direction for some products. They commended this innovation in development.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer highlighted the strong collaborations across national laboratories and industries that have been demonstrated under this project. They mentioned that these collaborations encompass a broad range of topics, including large-format cell fabrication, performance validation, and techno-economic modeling.

Reviewer 2:

The reviewer noted that the project's main charged task is to provide high-volume and large-format Li deposition services, and as such, they rely heavily on collaborators for cell manufacturing and testing, electrolyte development, and metrology support.

Reviewer 3:

The reviewer acknowledged that there is a significant number of contributors to this program, all making significant contributions based on their expertise.

Reviewer 4:

Despite some program delays, most of which were attributed to COVID-related events, the reviewer expressed that an excellent level of collaboration has been exhibited.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer noted that the future work for this project is well defined, particularly with a focus on cell fabrication by industrial partners and final performance validation by INL.

Reviewer 2:

The reviewer recommended approving the no-cost extension to allow the team to complete the listed works.

Reviewer 3:

The reviewer mentioned that the modeling suggests there is room for further improvements, which the team intends to pursue.

Reviewer 4:

The reviewer suggested that the team should emphasize which preferred coated products will be used in the final builds and make this information more explicit.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer expressed agreement with the project's relevance in supporting the needs of manufacturing high-energy density anodes, which is a focused area under the VTO program.

Reviewer 2:

The reviewer noted that developing high-volume manufacturing for large-format Li metal deposition capability contributes to building a strong US Li-ion battery industry.

Reviewer 3:

The reviewer acknowledged that the project is making significant advances in energy density and cost reduction for batteries related to the VTO program.

Reviewer 4:

The reviewer emphasized the importance of supporting advanced technology processes that benefit the US industrial workforce.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer affirmed that the project has access to significant resources through broad collaborations.

Reviewer 2:

The reviewer stated that the project is close to completion and can be completed with enough resources.

Reviewer 3:

The reviewer mentioned that the project is close to completion and can be successfully completed with the resources available.

Reviewer 4:

The reviewer found no issues with the funding or resource allocation for the project.

Presentation Number: BAT593
Presentation Title: Strategies to Enable Lean Electrolytes for High Loading and Stable Lithium-Sulfur Pouch
Principal Investigator: Shirley Meng (University of California at San Diego)

Presenter

Shirley Meng, University of California at San Diego

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

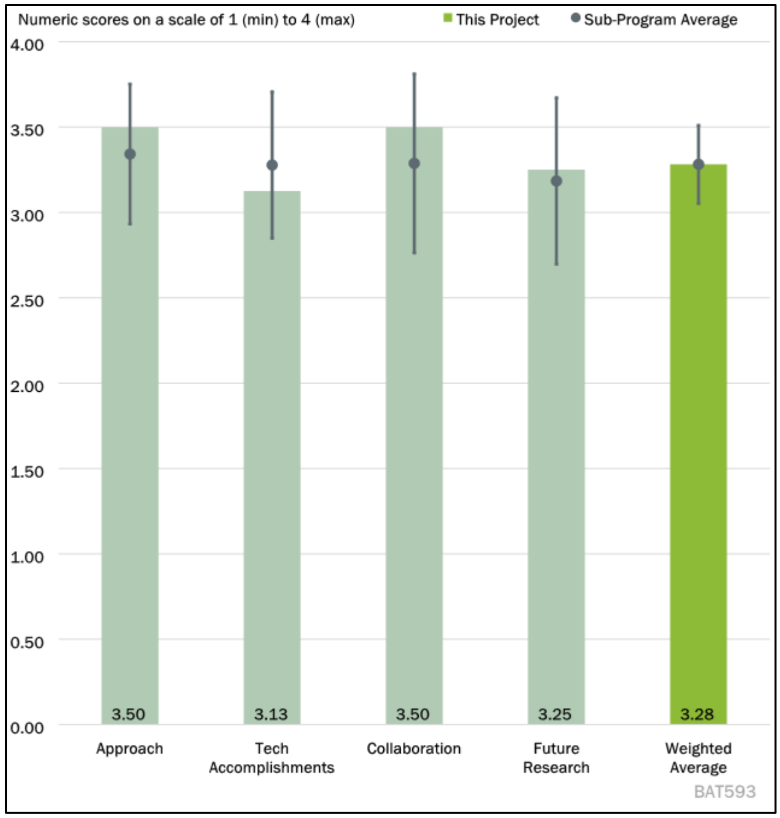

Figure 1-54 - Presentation Number: BAT593 Presentation Title: Strategies to Enable Lean Electrolytes for High Loading and Stable Lithium-Sulfur Pouch Principal Investigator: Shirley Meng (University of California at San Diego)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer stated "The project aims to enable lean electrolytes through the development of a strategy focused on creating and utilizing a dense stacking redox-active hexaazatrinaphthylene (HATN)-based cathode." It was noted that it remains unclear whether the approach prioritized cathode development or additive development to address polysulfide dissolution, which leads to sulfur inventory loss and continuous electrolyte consumption.

Reviewer 2:

The reviewer praised the work, remarking that it was excellent in the realm of thick, high-loading sulfur electrodes and electrolyte modifications. Specifically, the reviewer expressed that it effectively facilitated lean electrolyte cycling, which is deemed critical for achieving high Wh/kg cells.

Reviewer 3:

The reviewer articulated that the project, as reviewed, was well-designed to enhance and demonstrate the performance of Li-S cells with a capacity exceeding 1 Ah under conditions pertinent to practical cells. These conditions include a high capacity of 10 mAh/cm^2 and lean electrolyte environments. The overarching goal, as observed, is to align with DOE objectives of achieving high specific energy (more than 500 Wh/kg) and low cost ($80/kWh). The reviewer stated that the approach adopted involved the development of low-porosity, high-S loading cathodes featuring a redox-active HATN conjugated polymer. The project also includes efforts to identify life-limiting mechanisms, pinpoint advanced electrolytes functional at low E/S ratios, and devise methods to estimate sulfur and Li inventories during cycling. This review affirmed that the project is relevant to and consistent with DOE's mission of advancing battery technology (Li-S) with higher energy density, extended lifespan, and reduced cost compared to current Li-ion batteries used in EVs. The reviewer questioned the project's direction, identifying two key weaknesses: (1) Despite the promising nature of the electrolyte additive, the reviewer asked why the active material loadings examined in the project remained relatively low, not aligning with the stated target of 10 mAh/cm^2. Furthermore, it was observed that the E/S values appeared high, deviating from the requirements for high-energy cell designs; and (2) The reviewer also noted a discrepancy, as it seemed that the data presented here pertained to coin cells rather than the pouch cells mentioned in the project's stated objectives.

Reviewer 4:

Upon review, the reviewer verified that the project had concentrated its efforts on R&D endeavors aimed at enabling the operation of Li-S cells under lean electrolyte conditions. The approaches proposed, involving dense electrode materials, new electrolytes, and advanced characterization and quantification methodologies, were deemed scientifically sound and applicable to real-world conditions.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer observed that the identification of an additive to replace the conventional $LiNO_3$ showed promising improvements in cyclability. However, there were limitations due to Li inventory loss, and it was suggested that future work should establish a link between this loss and longer-term performance. On Slide 8, it was noted that the claim of 'good capacity retention' seemed overly optimistic, given that the cycle results were limited to 76 cycles, before any potential significant drop-off. Additionally, the reviewer pointed out that the claim of 65% capacity retention was not immediately evident from the data displayed. There appeared to be a discrepancy between the observed S inventory loss and polysulfide corrosion compared to the assessment of baseline performance.

Reviewer 2:

The reviewer remarked that preliminary cycling data was presented, showing relatively poor performance with a 35% fade in 75 cycles. It was acknowledged that this performance was being pushed to the limits of loading and electrolyte capacity.

Reviewer 3:

The reviewer commented on the progress made in demonstrating the fabrication of dense sulfur (S) cathodes with high loadings and low porosity (7 mAh/cm^2). However, it was highlighted that the electrode exhibited poor performance even at low rates (C/10) and demonstrated poor cycle life, even at high E/S ratios. The new electrolyte additive showed promise as a potential alternative to $LiNO_3$ in Li-S cells. Notably, the thermogravimetric analysis (TGA) of the cycled hexaazatrinaphthylene/carbon nanotube-sulfur (HATN/CNT-S) cathode revealed significant sulfur inventory loss. Additionally, severe polysulfide-induced corrosion in the cycled Li anode was observed. Two weaknesses were identified: (1) The test conditions employed, particularly E/S and N/P ratios, did not align with the targeted values for high-energy cells, and the cycle life of the dense cathode was suboptimal; and (2) The data presented appeared to pertain to coin cells, which may not fully align with the project's goals of pouch cell demonstration.

Reviewer 4:

The reviewer acknowledged that the project had made commendable progress in cathode materials, electrolyte development, and advanced characterization during the budget period. However, there were some technical questions that needed clarification. Notably, the cathode material had been previously reported by the team. It would be valuable to understand the differences or improvements achieved with the hexaazatrinaphthylene/carbon nanotube-sulfur (HATN/CNT-S) compared to the previous iteration. While the sulfur electrode had achieved the target mass loading of 5 mg/cm^2, it remained unclear what the sulfur utilization rate (mAh/g) was at such loading and low porosity. Furthermore, the proposed low E/S ratio of 3 g/Ah had not been applied in the cell tests, leaving uncertainties regarding how well the HATN/CNT or dense electrode functions under lean electrolyte conditions.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer noted that the project effectively manages the collaboration and roles of each contributor.

Reviewer 2:

The reviewer praised that the team is working alongside GM and Ampcera.

Reviewer 3:

The reviewer mentioned that there are ongoing collaborations with General Motors, led by Dr. Mei Cai, for pouch cell fabrication, and with Dr. Hui Du from Ampcera Inc for the scale-up of electrode materials. The reviewer suggested that it would be beneficial if the team could foster more collaboration with the B500 team, particularly concerning the determination of Li and S inventory losses in their systems.

Reviewer 4:

The reviewer acknowledged the project's strong collaborations with industries for materials scaling up and pouch validation.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer recommended that, given the limitations of the baseline data, more emphasis should be placed on identifying the limiting factors affecting cycle life under lean electrolyte conditions.

Reviewer 2:

The reviewer suggested that perhaps the scalable synthesis of this electrode should not be prioritized until there is a significant improvement in performance. The reviewer noted that improved cycle life and a better understanding of what is causing the fade are on the future task list, which is seen as a positive development.

Reviewer 3:

The reviewer acknowledged the proposed future studies as well-laid-out, starting with the identification of the life-limiting processes during cycling for Li-S under very lean electrolyte conditions. The plan includes establishing mitigation strategies to demonstrate improved cycle life compared to the baseline, with goals of achieving over 100 cycles and exceeding 300 Wh/kg. Additionally, there are plans to scale up fabrication methods for HATN polymer. However, the reviewer expressed uncertainty about what is being planned to decrease the cost of raw materials for Li-S cells toward DOE cost goals of less than $68/kWh. A weakness identified was that one or two tasks should be dedicated to demonstrating these materials in pouch cells and identifying and mitigating the pouch cell environment under lean electrolyte conditions.

Reviewer 4:

The reviewer concluded by acknowledging that the future research plan presented measurable deliverables, which was considered positive.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer emphasized that this project directly addresses the achievement of energy density and cost goals outlined in the VTO objectives, making it highly relevant.

Reviewer 2:

The reviewer noted by the reviewer that the project's relevance is underscored by the fact that sulfur (S) is abundant and offers high energy potential.

Reviewer 3:

The reviewer highlighted that the project aligns with the overall objectives of DOE by working towards the development of advanced Li-S cells with higher specific energy, lower cost, enhanced safety, and improved cycle life when compared to LIBs. It was also mentioned that while Li-S technology with liquid electrolytes presents challenges, this project is focused on mitigating the polysulfide shuttle and enhancing cycle life through the use of a new binder and electrolyte additive. Overall, the project's alignment with DOE VTO's Batteries subprogram objectives and goals was affirmed.

Reviewer 4:

The reviewer pointed out that the focused research on Li-S batteries directly supports VTO's vehicle electrification objectives by contributing to the development of high-energy and cost-effective energy storage technologies.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that the project funds are sufficient for achieving the goals of the project.

Reviewer 2:

The reviewer described the resources as reasonable.

Reviewer 3:

The reviewer noted that resources for the overall project are commensurate with the scope, which is seen as adequate to achieve the targeted milestones. However, there was a lack of clarity regarding the allocation of funds specifically for this team.

Reviewer 4:

The reviewer expressed that the team has sufficient resources to achieve the proposed research plan and milestones. Notably, collaborations with industries were highlighted as valuable resources that would support materials scaling up and pouch cell validation targets.

Presentation Number: BAT594
Presentation Title: New Engineering Concepts to High Energy Density Li-S Batteries
Principal Investigator: Prashant Kumta (University of Pittsburgh)

Presenter

Prashant Kumta, University of Pittsburgh

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 25% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

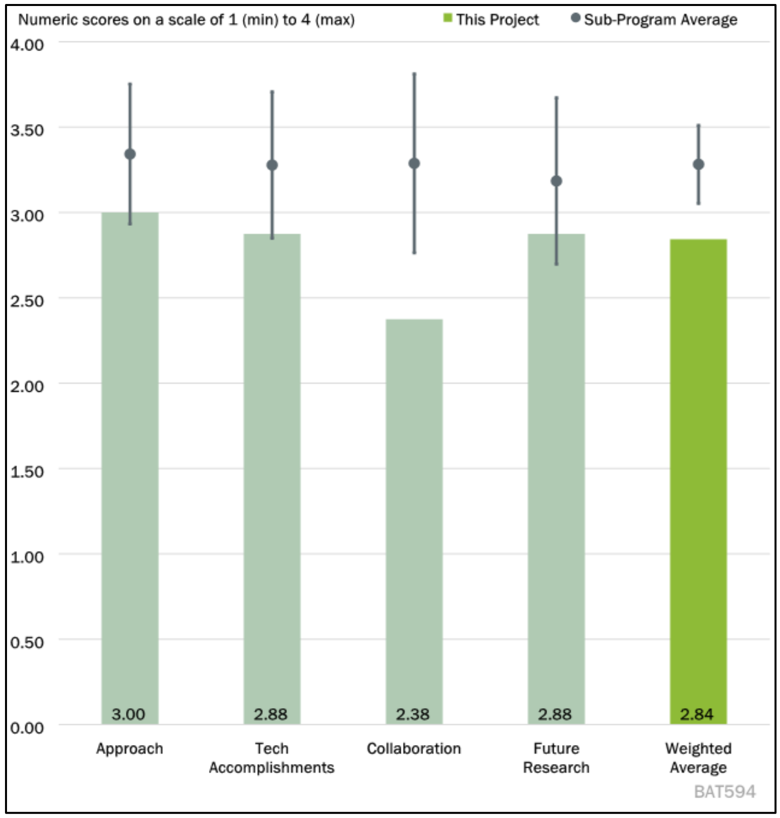

Figure 1-55 - Presentation Number: BAT594 Presentation Title: New Engineering Concepts to High Energy Density Li-S Batteries Principal Investigator: Prashant Kumta (University of Pittsburgh)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

In response to the project’s goals and approach, the reviewer noted that taking on the improvement of both the Li and sulfur electrodes is impressive for a project of this size. However, there were concerns about the battery design table, which outlines the ideas for achieving high specific energy, particularly the need for 15 mAh/cm^2 electrodes. The reviewer pointed out that this electrode size might be suitable for stationary applications but could pose challenges in transportation applications requiring higher discharge rates. Additionally, the high weight of the electrolyte in the cells was noted as an issue, suggesting high porosity in the electrodes. The reviewer expressed interest in seeing the cell’s volumetric energy density as well. The reviewer found it disappointing that the project lacked specifics on the exact methods and approaches being used, making it difficult to judge the uniqueness of the effort. They mentioned concerns about the lack of details on the composite alloy Li electrode and the shell-core structure for sulfur containment. While the importance of protecting intellectual property was acknowledged, the reviewer suggested finding a better balance.

Reviewer 2:

Regarding the project’s alignment with the B500 program’s needs for high-energy and long-life battery technology, the reviewer highlighted the focus on advancing Li-S technology through various components and modeling techniques. The project’s comprehensiveness and relevance to DOE goals for high-energy battery technology were acknowledged. However, the reviewer identified weaknesses in the project. Firstly, they believed that the project’s approach, while multipronged, did not adequately address the key barrier of the polysulfide shuttle and poor cycling, hindering the achievement of performance goals. Secondly, the reviewer found the technical milestones, especially the year 2 go/no-go milestone, to be too optimistic and unrealistic, particularly in achieving specific performance metrics.

Reviewer 3:

The reviewer concluded by recognizing the project's promising goals and practical targets but recommended that more research efforts be directed towards materials, electrode development, and cell-level integration to better approach and achieve these goals.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer acknowledged that the Li stripping and plating aspects appeared excellent, but they expressed confusion regarding why the utilization of S remained low. They noted that one of the project's goals is to make better use of the theoretical capacity of 1675 mAh/g, and none of the cathode constructions had come close to achieving that goal.

Reviewer 2:

The reviewer mentioned that there was a range of electrochemical technical results from the development of both electrodes, supported by theoretical calculations, indicating significant progress. However, they expressed uncertainty about whether all the Year 2 deliverables could be accomplished based on the presented results. The reviewer also noted that there appeared to be current efficiency issues with the cell, suggesting that not all the sulfur was contained.

Reviewer 3:

Regarding the identification of electrocatalysts and new Li alloys, the reviewer acknowledged that significant progress had been made, especially with ternary systems showing enhanced kinetics for reversible polysulfide conversion. They also noted the promising performance of the MCA4 alloy. New electrolyte additives and stabilization of the Li anode during plating and stripping were mentioned as accomplishments. Integration of these components into pouch cells with improved cycle life was also recognized. However, the reviewer pointed out several weaknesses in the project:

The achieved performance levels were considered promising but not on par with program goals. Achieving 500 Wh/kg and 1000 cycles was viewed as potentially unrealistic with the selected cell components, and there was a substantial risk of missing the year 2 go/no-go milestone.

The project lacked information on the chemistry or composition of the catalysts and alloys, which was considered unusual for a university-led and DOE-funded research project.

The reviewer suggested that the project did not appear to address the most significant deterrent mechanism, the polysulfide shuttle, with the current cathode design or other cell components. Additionally, the reviewer noted that the amount of electrolyte being used E/S was too high for the high specific energies targeted.

Reviewer 4:

The reviewer mentioned that while the team reported accomplishments in modeling, cathode materials, electrolyte additives, and Li anode current collector, they found it challenging to identify useful information on chemistry or composition throughout the report. They suggested that the project placed too much emphasis on simulation, which they deemed less relevant to the project's goals. Additionally, it was noted that many materials, including Li-ion conductor-carbon fiber mat-sulfur (LIC-CFM-S), had been reported previously, and it was unclear what new progress and improvements had been achieved in the budget period under this project.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer noted that there is little planned collaboration in the project, and they found this to be acceptable.

Reviewer 2:

The reviewer commented that collaboration appeared to be minimal, at best, based on the information available to them. They were surprised that there was limited collaboration even with the B500 team members.

Reviewer 3:

The reviewer identified the weakness that it would be helpful to have some form of collaboration, whether in the development of electrolytes or in the design and fabrication of pouch cells, possibly with a national laboratory or an industry partner within the B500 team.

Reviewer 4:

The reviewer pointed out that there was no collaboration slide included in the report, and they were unable to identify any collaborators. Blomgren Consulting, Ltd was mentioned in the overview slide, but their contributions were unclear.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer expressed that the project has a very full and comprehensive plan to address its remaining objectives.

Reviewer 2:

The reviewer noted that the PI seems determined to continue pushing the technology forward. However, due to the limited details provided, they found it challenging to suggest specific next steps.

Reviewer 3:

The reviewer commended plans for future studies as being well laid out. These plans include the development of the next generation of high sulfur-loaded CFM systems with electrocatalysts and Li-ion conductor (LIC) coatings derived from DFT calculations. Additionally, further development of the MCA alloy and the Li-SIA alloy (although it was noted that the nature of the latter is unclear) and the identification of new electrolyte additives with reduced polysulfide solubility were mentioned. These studies were seen as aligned with the initial proposals and were expected to address issues related to the slow kinetics of solid polysulfides and the performance losses caused by the sulfide shuttle. However, the reviewer identified weaknesses in the project:

The reviewer expressed doubts about the project's ability to significantly improve the performance of Li-S cells to levels close to the targeted goals, particularly in terms of catalysts, alloys, electrolytes, and the CFM sulfur cathode.

The project was noted to be similar to another project being conducted by the same team, with the primary difference being the sulfur host material (carbon to ceramic). The reviewer raised concerns about the extent of overlap between the two projects and suggested that consolidation might be necessary.

Reviewer 4:

The reviewer found that there was no reasonable action plan closely adhering to the upcoming measurable milestones or go-no/go goals. The reviewer believed that giving experimental work a higher priority over simulation could aid in achieving the Year 2 goals.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer emphasized the high relevance of the project, particularly highlighting the need for high-loading and highly utilized sulfur (S) electrodes.

Reviewer 2:

The reviewer stated that the work is very relevant to the advancement of battery technology.

Reviewer 3:

The reviewer pointed out that the project aligns with the overall objectives of DOE by working towards the development of advanced Li-S cells with higher specific energy, lower cost, enhanced safety, and improved cycle life compared to LIBs. The challenge posed by the polysulfide shuttle in Li-S technology with liquid electrolytes was acknowledged, and the project was noted to focus on mitigating this issue while improving cycle life using new sulfur hosts, catalysts, anodes, and electrolyte additives. Overall, the project was seen as relevant to VTO Batteries subprogram objectives and goals.

Reviewer 4:

The reviewer recognized the promising advantages of Li-S battery technology in terms of energy density, safety, and cost. They stated that the success of the project would directly support the VTO's objectives of vehicle electrification and decarbonization.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer found that the resources allocated to the project were reasonable and represented good value for the research and development investment.

Reviewer 2:

The reviewer noted that the PI had promised a lot for the funds available, but the PI was clearly attacking all the major challenges of the technology, which is impressive.

Reviewer 3:

The reviewer mentioned that the resources for the overall project appeared to be commensurate with the scope and adequate to achieve the targeted milestones.

Reviewer 4:

The reviewer suggested that while the team had sufficient resources, it was essential for the team to prioritize their research efforts towards the project goals.

Presentation Number: BAT595
Presentation Title: Development of Li-S Battery Cells with High Energy Density and Long Cycling Life
Principal Investigator: Donghai Wang (Penn State University)

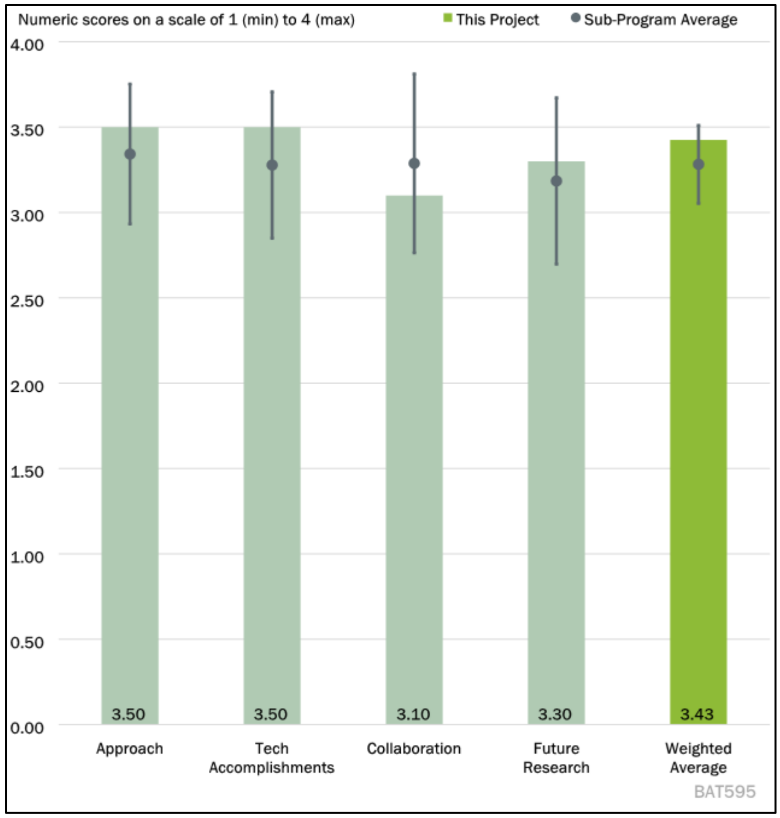

Figure 1-56 - Presentation Number: BAT595 Presentation Title: Development of Li-S Battery Cells with High Energy Density and Long Cycling Life Principal Investigator: Donghai Wang (Penn State University)

Presenter

Donghai Wang, Penn State University

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer remarked that the project has a well-defined approach to developing sulfurized polymer composite (SPC) active material to mitigate capacity fade caused by Li inventory loss, specifically polysulfide formation and shuttling.

Reviewer 2:

The reviewer praised the project for its effective strategy in developing high-loading sulfur cathodes and stable electrolytes.

Reviewer 3:

The reviewer expressed that the approach of attaching sulfur to a polymer backbone to prevent polysulfide dissolution in the electrolyte has been shown to be valid. The reviewer mentioned the use of polyacrylonitrile (PAN), in previous literature and noted the undisclosed polymer used by the PI. Furthermore, the reviewer questioned the need for a simple calculation regarding cell-specific energy and energy density and expressed a desire for more interaction with the PI.

Reviewer 4:

The reviewer stated that the project is well-designed to develop Li-S cells with sulfurized polymers as active material to address the polysulfide shuttle problem and extend cycle life, albeit with lower specific energies. The reviewer outlined specific objectives related to sulfur composite materials, binders, and diagnostics.

Additionally, the reviewer questioned the feasibility of certain energy goals and the necessity for a high E/S in a cathode without soluble polysulfides.

Reviewer 5:

The reviewer affirmed that the project proposes to use SPCs and functional binders to resolve polysulfide-related issues in liquid Li-S batteries. The reviewer commended the project for its approach, which draws on careful investigation of state-of-the-art techniques and proven effectiveness.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer noted that the technical accomplishments indicate good stable performance with a high E/S and specific capacity retention relative to conventional baseline approaches.

Reviewer 2:

The reviewer expressed curiosity about the plot shown on Slide 13 with the 4 mAh/cm^2 sulfur cathode, particularly regarding the discrepancy between the goal of 1000 mAh/g and the specific capacity not being shown. The sharp drop-off in capacity observed at around 120 cycles also raised questions about its cause.

Reviewer 3:

The reviewer acknowledged the PI’s clear progress while also suggesting that there is still work to be done to reduce the E/S ratio and increase the aerial capacity. Furthermore, the reviewer mentioned the desire to see efficiency presented on an expanded scale. The analytical work indicated that the polymer may not completely hold the sulfur, and it would be beneficial to determine whether the issue lies in sulfur detachment from the polymer during cycling. The reviewer suggested conducting cycle life studies at relatively high rates, ideally C/3 or higher, and increasing the number of cycles. The potential use of a thick lithium titanium oxide (LTO) electrode as a replacement for the Li electrode was also mentioned.

Reviewer 4:

The reviewer commended the project’s progress in synthesizing new SPC material, which demonstrated a higher discharge capacity of 1000 mAh/g, showed the generation of polysulfides in carbonate electrolytes, and exhibited better kinetics compared to conventional sulfurized polyacrylonitrile (SPAN) materials. The redox behavior of SPC, including lithiation and delithiation, was well-characterized. Additionally, a SPC-based cathode with a moderate aerial capacity (4 mAh/cm^2) and a polymeric binder was fabricated, demonstrating fairly decent cycle life. However, the reviewer pointed out several weaknesses: (1) The discharge voltage is too low, making a 4 mAh/cm^2 aerial capacity inadequate to provide sufficient energy, especially with an E/S of 5; (2) The cycle life of 150 cycles is not impressive, especially considering the absence of a sulfide shuttle; (3) The reviewer emphasized the need for a working performance model to guide the project and determine key performance parameters of the cell components, as well as the expected specific energy at the prototype pouch cell level (which should be at least 250 Wh/kg); and (4) Lastly, the reviewer emphasized the importance of demonstrating specific energy and cycle life at the pouch cell level to establish the project’s high relevance to DOE goals.

Reviewer 5:

The reviewer concluded by highlighting the team’s successful development of the SPC cathode, compatible binder, and their deep understanding of the reaction mechanism. The material’s impressive performance in a Li-S coin cell, outperforming conventional SPAN materials, indicated a good potential for practical cell demonstration. The use of carbonate-based electrolytes was also noted as advantageous in terms of durability and safety, although the reviewer mentioned that addressing the issue of low first-cycle efficiency would be a future focus of the project.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer commented that it is unclear what role the UIC (University of Illinois at Chicago) team contributes to the project.

Reviewer 2:

The reviewer commended the PI for reaching out to collaborators to assist with some of the analytical studies.

Reviewer 3:

The reviewer cited ongoing collaborations with the University of Illinois at Chicago and the Brookhaven National Laboratory. The latter is being utilized for XAS and PDF experiments, but it is not clear what UIC is subcontracted for, perhaps DFT calculations? A suggestion by the reviewer was that it would be useful to collaborate with an industrial partner or, at the very least, a national laboratory (e.g., PNNL or INL) to demonstrate the materials in pouch cells in parallel with material development.

Reviewer 4:

The reviewer noted that the team has good collaborations with other universities and national laboratories for modeling and advanced characterization.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer stated that the future work related to the SPC is identified and consistent with the project objectives. However, the reviewer pointed out that while the goal of improved polymer binder development is important, the proposed future effort toward this goal is not thoroughly identified. Based on the results and analysis, specific directions for this aspect are not readily apparent.

Reviewer 2:

The reviewer remarked that the project is focused on the correct issues as expected.

Reviewer 3:

The reviewer expressed concern that there are not a lot of specifics in the future work. The impression given is that the PI believes they have what they need to reach their goals and only need to optimize things. The reviewer remained unconvinced by this approach.

Reviewer 4:

The reviewer acknowledged that there are still significant challenges in achieving high specific capacity without generating soluble polysulfides with the SPC materials and in achieving good performance in higher aerial-capacity cathodes at low E/S and N/P. The proposed future studies are seen as partially addressing these challenges, such as developing and demonstrating a high capacity of 800 mAh with SPC-based cathode materials in optimized electrolytes without polysulfide generation and achieving good cycle life. The reviewer also noted the plan to fabricate cathodes with higher aerial capacity using new polymer binders. A weakness highlighted by the reviewer was the need for a performance model that supports the performance goals, demonstrating that with these performance values, a high specific energy of at least 250 Wh/kg is possible. Additionally, the reviewer emphasized the necessity for quantification of the targeted cycle life.

Reviewer 5:

The reviewer recognized that the proposed future research aims to further improve the specific capacity of cathode material and the processing of high mass loading electrodes, which are considered reasonable and relevant to the high-energy target. Furthermore, the reviewer mentioned that future research would focus on understanding and addressing the issue of low first-cycle efficiency.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer affirmed that this project is directly relevant to the energy density and cost goals of the VTO subprogram objectives.

Reviewer 2:

The reviewer noted that the project is highly relevant for next-generation batteries using earth-abundant materials.

Reviewer 3:

The reviewer expressed that this work is very relevant to the battery area.

Reviewer 4:

The reviewer emphasized that the project supports the overall DOE objectives by developing advanced Li-S cells with higher specific energy, lower cost, enhanced safety, and improved cycle life compared to LIBs. They mentioned that Li-S technology with liquid electrolytes and elemental sulfur faces challenges due to the persistent polysulfide shuttle, which limits cycle life. However, this project is focused on mitigating the polysulfide shuttle and improving cycle life with SPC cathodes without soluble polymers, thereby expectedly achieving good cycle life, albeit at lower energy. In summary, the project aligns with the DOE VTO's battery program's objectives and goals.

Reviewer 5:

The reviewer pointed out that Li-S battery technology is a promising energy storage technology due to its high energy and low cost. They highlighted that the success of the project directly supports VTO's objectives of vehicle electrification and decarbonization.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that the resources assigned and utilized by this project are sufficient for the completion of the project goals.

Reviewer 2:

The reviewer commented that the funding seems good for what the PI is trying to accomplish.

Reviewer 3:

The reviewer expressed that resources for the overall project are commensurate with the scope and adequate to achieve the targeted milestones.

Reviewer 4:

The reviewer affirmed that the team has sufficient resources and experience to achieve the proposed milestones, both through their own capabilities and through collaboration with other institutes.

Presentation Number: BAT596
Presentation Title: Development of a High-Rate Li-Air Battery using a Gaseous CO_2 Reactant
Principal Investigator: Amin Salehi-Khojin (University of Illinois at Chicago)

Presenter

Amin Salehi-Khojin, University of Illinois at Chicago

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

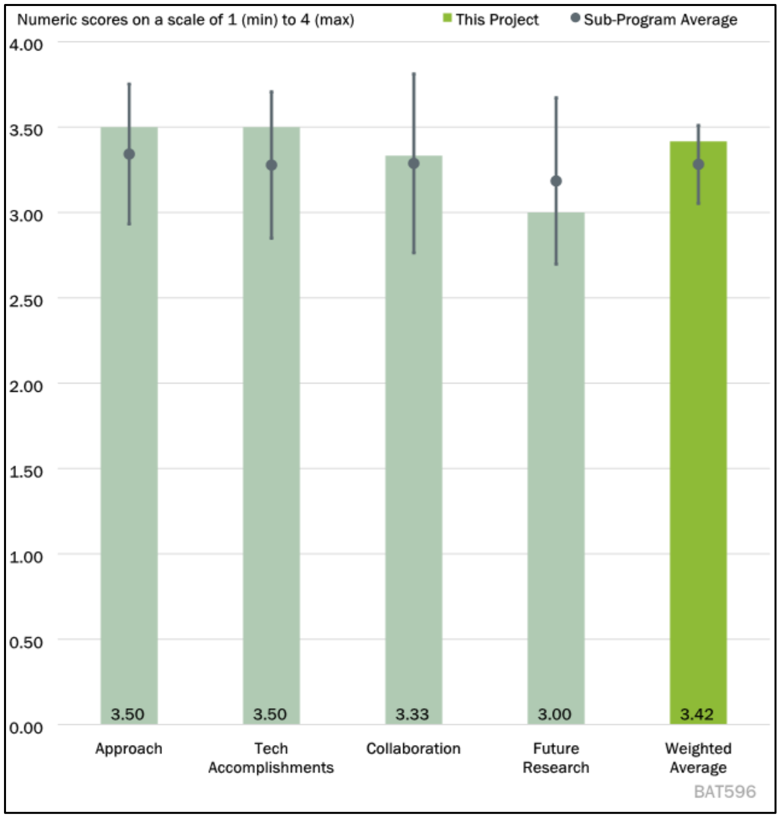

Figure 1-57 - Presentation Number: BAT596 Presentation Title: Development of a High-Rate Li-Air Battery using a Gaseous CO_2 Reactant Principal Investigator: Amin Salehi-Khojin (University of Illinois at Chicago)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer provided a comprehensive evaluation of the project, which focuses on the development of a layered sulfide catalyst (niobium, tantalum, bismuth sulfide) to facilitate efficient and reversible Li-CO_2 electrochemistry. The catalyst material is synthesized with high purity and characterized by the PIs. CO_2 electrochemistry is explored using an ionic liquid/dimethyl sulfoxide electrolyte with the sulfide catalyst and selected control catalysts (Pt, Au, and C). The reviewer noted the observation of high current densities at a given applied overpotential for the sulfide catalysts and good voltage stability during galvanostatic cycling. Qualitative characterization of the products suggests consistency with Li_2CO_3 and pure carbon formation. However, the reviewer pointed out that it remains unclear from the results if this reaction is reversible. DFT calculations are employed to identify niobium surface sites as the likely catalytic sites for the reaction. In summary, the project is well-designed, with a reasonably planned timeline, and addresses key technical barriers related to the kinetics of CO_2 reduction. The reviewer also recommended further investigations into the charge process and electrolyte stability in the presence of carbonate and carbon oxidation in subsequent years.

Reviewer 2:

The reviewer acknowledged the significant challenges in developing a Li-air battery based on CO_2 as a reactant and commended the team for addressing these challenges with a well-thought-out plan. The integrated approach, which encompasses materials synthesis, testing, characterization, and computation, is considered effective in improving cell reversibility and rate capability. The milestones and timeline were deemed appropriate.

Reviewer 3:

The reviewer praised the project's excellent approach, highlighting the critical role of electrolyte and catalyst in the performance of Li-CO_2 batteries. They specifically appreciated the focus on developing a novel catalyst, which yielded very promising results.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer summarized the technical accomplishments of the project and noted that overall, the project has made very good progress in the past year.

Reviewer 2:

The reviewer highlighted significant progress made by the team, including the identification of a new medium-entropy cathode catalyst and an ionic liquid-based electrolyte blend that allowed for electrochemistry to operate at current densities of 0.5 mA/cm^2 for 125 cycles. This achievement was noted to exceed reports in the literature.

Reviewer 3:

The reviewer praised the PI for synthesizing and characterizing a new catalyst, $(NbTa)_{0.5}BiS_3$, which demonstrated excellent CO_2 reduction and evolution reaction capabilities. When used with a dimethyl sulfoxide/ionic liquid (DMSO/IL) electrolyte, excellent cycling stability was achieved. The group's characterization of reduction and oxidation products on the cathode and anode, along with the verification of the proposed reaction mechanism, was seen as establishing a solid foundation for further development of Li-CO_2 batteries.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer observed that the project appears to be collaborative, although it is not clear which team members performed the various studies throughout. However, they noted that collaboration appears good, given the number of different characterization techniques employed.

Reviewer 2:

The reviewer expressed that a good team, consisting of both experimentalists and theoreticians, has been assembled to address the scientific challenges of a Li-CO_2 battery. The team includes members from ANL, the University of Illinois Chicago, and Stockholm University. The absence of industrial partners was mentioned but considered unnecessary at this stage of development.

Reviewer 3:

The reviewer highlighted that the PI has established broad collaborations with other groups actively working in this field, including L. Curtiss (ANL), J. Cabana (UIC), Z. Huang (Stockholm University, Sweden), and A. Subramanian (UIC), among others.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer noted that future research is relatively sparse, offering only high-level directions without providing specific details on how those directions would be achieved through additional science and engineering. However, they mentioned that the three directions provided appear to be reasonable.

Reviewer 2:

The reviewer characterized the proposed future research plan as vague but considered the overall approach to design more stable materials and increase rate capability to be reasonable, based on the results achieved so far.

Reviewer 3:

The reviewer highlighted the PI's proposal to focus on increasing the rate capability of Li/CO_2 batteries in their future work. They emphasized that rate capability is one of the key barriers in these batteries and viewed this research plan as a logical next step.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer recognized that the project focuses on an emerging battery chemistry that faces kinetics limitations and is relevant to the VTO's battery portfolio.

Reviewer 2:

The reviewer emphasized the relevance of this project to VTO. They noted that Li-air or Li-CO_2 batteries are considered potential alternatives to Li-ion batteries for transportation applications due to their high theoretical specific energy. Batteries utilizing CO_2 are known for their very high theoretical specific energy density. The reviewer mentioned that this project is expected to contribute to a comprehensive understanding of key chemical and electronic parameters governing the operation of Li-CO_2 batteries under realistic conditions.

Reviewer 3:

The reviewer stated that the project is an integral part of the VTO portfolio for the next generation of high-energy batteries. They characterized it as a high-risk, high-reward project that can significantly contribute to the knowledge base of energy storage. If the battery technology can be successfully scaled up, it was noted that it would also align with DOE's overall goal of CO_2 reduction.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that the resources are sufficient.

Reviewer 2:

The reviewer commented that the project appears to have the necessary resources to achieve the milestones in a timely fashion.

Reviewer 3:

The reviewer affirmed that the resources of the project are sufficient.

Acronyms and Abbreviations – BAT

Abbreviation	Definition
3D	Three-dimensional
^{7}Li NMR	Lithium nuclear magnetic resonance spectroscopy
AFLB	Anode-free lithium-ion batteries
AG	Artificial graphite
Ah	Ampere-hour
ALD	Atomic layer deposition
ALS	Advanced Light Source
ANL	Argonne National Laboratory
APS	Advanced Photon Source
ARL	Army Research Laboratory
ASE	Argyrodite-type solid electrolytes
ASSLSB	All-Solid-State Lithium-Sulfur Battery
B500	Battery 500 Consortium
BAT	VTO Battery Advanced Technology subprogram
BCDI	Bragg coherent diffraction imaging
BIL	Bipartisan Infrastructure Law
BMR	Battery Materials Research
BNL	Brookhaven National Laboratory
BP	Budget Period
CAM	Cathode active materials
CAMP	Cell Analysis, Modeling, and Prototyping (CAMP) Facility
CCD	Critical current density
CE	Coulombic efficiency
CEI	Cathode electrolyte interphase
CFM	Carbon fiber mat
CNT	Carbon nanotube
CNT-S	Carbon nanotube-sulfur
Co	Cobalt
CO_2	Carbon dioxide

Abbreviation	Definition
COVID	Coronavirus disease (COVID-19), infectious disease caused by the SARS-CoV-2 virus
CRADA	Cooperative Research and Development Agreement
CSTR	Continuous stirred-tank reactor
Cu	Copper
DCDI	Diffraction contrast diffractive imaging
DFT	Density functional theory
DHM	Digital holographic microscopy
DMSO/IL	Dimethyl sulfoxide/ionic liquid
DOE	U.S. Department of Energy
dP/dV	Change in pressure with change in voltage
dQ/dV	Change in voltage with change in capacity
DRX	Disordered rock salt
DST	Dynamic stress test
EaCAM	Earth-abundant cathode materials
EB	Electron-beam
EDS	Energy-dispersive X-ray spectroscopy
EERE	Office of Energy Efficiency and Renewable Energy
EIC	Electron-Ion Collider
EIS	Electrochemical impedance spectroscopy
EM	Electron microscopy
EOCV	Electrochemical open circuit voltage
EOL	End-of-life
EP	Electropolymerization
EPA	U.S. Environmental Protection Agency
ESI/MS	Electrospray ionization / mass spectrometry
EV	Electric vehicle(s)
FDMB	Fluoro-dimethoxylbutane
FEC	Fluoroethylene carbonate
FLHCE	Fluorinated lean high-capacity electrolyte
FMMB	2-Fluoro-1-methoxy-4-(methylsulfonyl)benzene, also known as FMMB, an organosulfur compound

Abbreviation	Definition
FOA	Funding opportunity announcement
FSI	Fluoromethanesulfonimide
FSP	Flame spray pyrolysis
FTIR	Fourier transform infrared spectroscopy
GDOES	Glow discharge optical emission spectrometry
GHG	Greenhouse gas
GIXRD	Grazing incidence X-ray diffraction
GM	General Motors
HATN	Hexaazatrinaphthylene
HATN/CNT	Hexaazatrinaphthylene/carbon nanotube
HATN/CNT-S	Hexaazatrinaphthylene/carbon nanotube-sulfur
HAXPES	Hard X-ray photoelectron spectroscopy
HFE	Fluorinated ether
HPLC	High-performance liquid chromatography
HVM	High-volume manufacturing
IC	Ionic conductivity
ID	Identification
INL	Idaho National Laboratory
Kg	Kilogram
kWh	Kilowatt-hour
LBL	Lawrence Berkeley National Laboratory
LC	Liquid chromatography
LFP	Lithium iron phosphate
LHCE	Lean high-capacity electrolyte
Li	Lithium
Li_2S	Lithium sulfide
LIB	Lithium-ion battery
LiB_xS_y	Any compounds including lithium, boron and sulfur
LIC	Lithium-ion conductor
LiFSI	Lithium bis(fluorosulfonyl)imide
$LiNO_3$	Lithium nitrate

Abbreviation	Definition
LiP_xS_y	Any compounds including lithium, phosphate and sulfur
LiS or Li-S	Lithium sulfur
LiTFSI	Lithium bis(trifluoromethanesulfonyl)imide
LLTO	Lithium lanthanum titanate oxide
LLZO	Lithium lanthanum zirconate
LLZTO	Garnet-type fast lithium-ion conductor $Li_{6.75}La_3Zr_{1.75}Ta_{0.25}O_{12}$
LMFP	Lithium iron phosphate ($LiFePO_4$) cathode material with manganese (Mn)
LMR	Lithium metal rich
LMR-NMC	Lithium manganese rich-nickel manganese cobalt material.
LNMO	Lithium-nickel-manganese oxide
LSE	Lithium solid electrolyte
LTO	Lithium titanium oxide
mA	Milliampere
mAh	Milliampere-hour
MCA	Magnetocrystalline anisotropy
MERF	Materials Engineering Research Facility
METS	Multiharmonic electrothermal microscopy
MHP	Mixed hydroxide precipitate
ML	Machine learning
Mn	Manganese
MS	Mass spectrometry
N/P	Negative-to-positive ratio
NC	Nitrogen doped (N-Doped) carbon
NCA	Nickel cobalt aluminum
NCM	Lithium nickel manganese cobalt oxides (abbreviated NMC, Li-NMC, LNMC, or NCM) are mixed metal oxides of lithium, nickel, manganese and cobalt
NG	Natural gas
Ni	Nickel
NIST	National Institute of Standards and Technology
NMC	Nickel manganese cobalt

Abbreviation	Definition
NMP	N-methyl-2-pyrrolidone
NMR	Nuclear magnetic resonance spectroscopy
NREL	National Renewable Energy Laboratory
NSLS	National Synchrotron Light Source
ORNL	Oak Ridge National Laboratory
P2D	Pouch-to-depletion
PAN	Polyacrylonitrile
PDF	Pair distribution function
PEGDA	Polyethylene glycol diacrylate polymer
PEV	Plug-in electric vehicle
PI	Principal investigator
PMTH	Thiuram polysulfides
PNNL	Pacific Northwest National Laboratory
POFM	Porous organometallic framework materials
PUA	Polyurethane acrylate
PV	Photovoltaic
PVDF	Polyvinylidene fluoride
PWA	Powdered activated carbon
PXRD	Powder X-ray diffraction
Q1, Q2, Q3, or Q4	Annual quarters
R&D	Research and development
RDD&D	Research, development, deployment, and demonstration
RPT	Rate performance test
S	Sulfur
SCHT	Supercritical hydrothermal
SCSA	Sulfur cathode structure/architecture
Se	Selenium
SEI	Solid-electrolyte interface/interphase
SEM	Scanning electron microscopy
SeS	Selenium sulfide
Si	Silicon

Abbreviation	Definition
SLPC	Single-layer pouch cells
Sn	Tin
SOC	State of charge
SOH	State of health
SP	Solution precipitation
SPAN	Sulfurized polyacrylonitrile
SPC	Sulfurized polymer composite
SPE	Solid polymer electrolyte
SSB	Solid-state battery
SSE	Solid-state electrolyte
TCI	Lithium tricyanoimidazole
TEA	Techno-economic analysis
TEGDME	Tetra (ethylene glycol) dimethyl ether
TEM	Transmission electron microscopy
TGA	Thermogravimetric analysis
ToF SIMS	Time-of-flight secondary ion mass spectrometry
TRL	Technology readiness level
TVR	Thermal vapor recompression
UC	University of California
UIC	University of Illinois at Chicago
UMD	University of Maryland
US	United States
USABC	U.S. Department of Energy/U.S. Advanced Battery Consortium, a subsidiary of USCAR
UV	Ultraviolet
UW	University of Washington
VED	Volumetric energy density
VTO	Vehicle Technologies Office
W	Tungsten
XAS	X-ray absorption spectroscopy
XCEL	eXtreme Fast Charge Cell Evaluation of Lithium-Ion Batteries

Abbreviation	Definition
XFC	Extreme fast charging
XPS	X-ray photoelectron spectroscopy
XRD	X-ray diffraction
XRD/XAS	X-ray Diffraction/X-ray Absorption Spectroscopy

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2. Electrification

The Vehicle Technologies Office (VTO) supports research, development, demonstration, and deployment (RDD&D) of new, efficient, and clean mobility options that are affordable for all Americans. The office's investments leverage the unique capabilities and world-class expertise of the national laboratory system to develop new innovations in vehicle technologies, including: advanced battery technologies; advanced materials for lighter-weight vehicle structures and better powertrains; energy-efficient mobility technologies and systems (including automated and connected vehicles as well innovations in connected infrastructure for significant systems-level energy efficiency improvement); innovative powertrains to reduce greenhouse gas (GHG) and criteria emissions from hard to decarbonize off-road, maritime, rail, and aviation sectors; and technology integration that helps demonstrate and deploy new technology at the community level. In coordination with the other offices across the Office of Energy Efficiency and Renewable Energy (EERE) and the U.S. Department of Energy (DOE), VTO advances technologies that assure affordable, reliable mobility solutions for people and goods across all economic and social groups; enable and support competitiveness for industry and the economy/workforce; and address local air quality and use of water, land, and domestic resources.

The Electrification subprogram supports the decarbonization of transportation across all modes, serves to increase American advancement/manufacturing of battery technology, and creates good paying jobs with the free and fair chance to join a union and bargain collectively. The subprogram supports research with partners in academia, national laboratories, and industry covered under the Energy Storage Grand Challenge key priority and four distinct crosscuts including: Critical Materials, Grid Modernization, Advanced Manufacturing, and Energy Sector Cybersecurity.

The Electric Drive research and development (R&D) activity supports R&D for extreme high-power density electric drive systems that have the potential to enable radical new vehicle architectures by dramatic volume/space reductions and increased durability and reliability. The cost of electric traction drive systems, including power electronics and electric motors, will be reduced through high-density integration technologies, novel circuit topologies, new materials for high-density electric motors, and leveraging high performance computing for modeling and optimization. VTO will use electric traction drive system design, integration, and testing to verify performance and progress towards meeting R&D targets.

Electrification R&D: The Electrification R&D activity supports R&D to understand the potential impacts on, and benefits of, EV charging to the Nation's electric grid. This research will inform the development of communication and cybersecurity protocols; enable industry to enhance the interoperability between charging equipment, the on-board vehicle charger, and charging networks; and foster technology innovations to improve plug-in electric vehicle (PEV) refueling through extreme fast charging. Core research focuses on developing EV charging, charge management, distributed energy resources (DER) integration, grid services, and cyber-physical security technologies for reliable and cost-effective charging of light-, medium-, and heavy-duty (HD) electric vehicles (EV). This includes technical support and research for technologies related to cybersecurity for electric vehicle charging/supply equipment, and integration with the electric grid.

Project Feedback

In this merit review activity, each reviewer was asked to respond to a series of questions, involving multiple-choice responses, expository responses where text comments were requested, and numeric score responses (on a scale of 1.0 to 4.0). In the pages that follow, the reviewer responses to each question for each project will be summarized: the multiple choice and numeric score questions will be presented in graph form for each project, and the expository text responses will be summarized in paragraph form for each question. A table presenting the average numeric score for each question for each project is presented below.

Table 2-1 – Project Feedback

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
ELT158	Zero-Emission Cargo Transport II, San Pedro Bay Ports Hybrid & Fuel-Cell Electric Vehicle Project	Seungbum Ha (South Coast Air Quality Management District [SCAQMD])	2-6	3.33	2.92	3.58	3.08	3.13
ELT179	Low Cost, High-Performance, Heavy Rare-Earth-Free 3-In-1 Electric Drive Unit	David Crecelius (American Axle & Manufacturing)	2-12	3.50	3.33	3.00	3.33	3.33
ELT197	High Power and Dynamic Wireless Charging of Electric Vehicles	Veda Galigekere (Oak Ridge National Laboratory)	2-15	3.60	3.60	3.40	3.30	3.54
ELT208	Highly Integrated Power Module	Lincoln Xue (Oak Ridge National Laboratory)	2-20	3.33	3.33	3.50	3.17	3.33
ELT209	High-Voltage, High-Power Density Traction-Drive Inverter	Gui-Jia Su (Oak Ridge National Laboratory)	2-23	3.25	3.63	3.13	3.38	3.44
ELT211	Power Electronics Thermal Management	Gilbert Moreno (National Renewable Energy Laboratory)	2-27	3.67	3.67	3.58	3.17	3.59
ELT215	Develop fine-grain RE permanent magnet with high coercivity at high temperature AND cost-effective manufacturing process for high performance soft magnetic materials in thin sheet form	Iver Anderson (Ames Laboratory)	2-32	3.00	3.10	2.80	3.00	3.03

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
ELT216	Isotropic, Bottom-Up Soft Magnetic Composites for Rotating Machines	Todd Monson (Sandia National Laboratories)	2-36	3.30	3.30	3.40	3.30	3.31
ELT219	Power Electronics Materials and Bonded Interfaces-Reliability and Lifetime	Paul Paret (National Renewable Energy Laboratory)	2-40	3.42	3.42	3.17	3.42	3.39
ELT221	Integrated Electric Drive System	Shajjad Chowdhury (Oak Ridge National Laboratory)	2-44	3.00	3.25	3.13	3.13	3.16
ELT223	Component Testing, Co-Optimization, and Trade-Space Evaluation	Jason Neely (Sandia National Laboratories)	2-47	3.33	3.33	2.83	3.33	3.27
ELT236	Direct-Current Conversion Equipment Connected to the Medium-Voltage Grid for Extreme Fast Charging Utilizing Modular and Interoperable Architecture	Watson Collins (Electric Power Research Institute)	2-50	3.38	3.00	3.00	3.38	3.14
ELT238	Intelligent, Grid-Friendly, modular Extreme Fast Charging System with Solid-State Direct-Current Protection	Srdjan Lukic (North Carolina State University)	2-54	3.67	3.50	3.50	3.25	3.51
ELT239	High-Power Inductive Charging System Development and Integration for Mobility	Omer Onar (Oak Ridge National Laboratory)	2-58	3.50	3.50	3.38	3.50	3.48
ELT240	Wireless Extreme Fast Charging for Electric Trucks (WXFC-Trucks)	Ryan Calder (WAVE, Inc.)	2-62	2.83	3.00	2.83	3.00	2.94
ELT252	Wound-Field Synchronous Machine-System Integration toward Increased Power Density and Commercialization	Lakshmi Iyer (Magna Services of America Inc)	2-65	3.25	3.75	3.25	3.00	3.47

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
ELT255	Cost-Effective, Rare-Earth-Free, Flux-Doubling, Torque-Doubling, Increased Power Density Traction Motor with Near-Zero Open-Circuit Back-Electromagnetic Field and No-Cogging Torque	Jim Gafford (University of North Carolina at Charlotte)	2-68	2.83	3.00	3.00	2.83	2.94
ELT260	Improving the Freight Productivity of a Heavy-Duty, Battery Electric Truck by Intelligent Energy Management	Teresa Taylor (Volvo)	2-70	2.75	2.75	2.83	2.50	2.73
ELT261	High-Efficiency Powertrain for Heavy-Duty Trucks using Silicon Carbide Inverter	Steve Peelman (Ricardo)	2-75	3.33	3.17	3.00	3.33	3.21
ELT262	Long-Range, Heavy-Duty Battery-Electric Vehicle with Megawatt Wireless Charging	Ryan Reed (Kenworth)	2-78	3.00	3.13	3.00	3.00	3.06
ELT264	Demonstration of Utility Managed Smart Charging For Multiple Benefit Streams	Stephanie Leach (Exelon/Pepco Holdings Inc.)	2-81	3.25	3.25	3.00	3.25	3.22
ELT265	A Secure and Resilient Interoperable SCM Control System Architecture for Electric Vehicle's-At-Scale	Duncan Woodbury (Dream Team LLC)	2-84	3.00	3.00	3.00	3.00	3.00
ELT274	eMosaic, Electrification Mosaic Platform for Grid-Informed Smart Charging Management	Alex Brissette (ABB)	2-87	3.33	3.17	3.17	2.67	3.15
ELT278	EVs@Scale Lab Consortium	Andrew Meintz (National Renewable Energy Laboratory)	2-90	3.00	2.83	2.50	3.00	2.85

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
ELT282	Technology & Design Innovations to Maximize the Reduction Effect on DCFC Unit Cost Economics (Max-REDUCE)	Robert Keefover (Borg Warner)	2-94	3.50	3.25	3.25	2.25	3.19
ELT283	A Solid State Technology Enabled Compact, Modular Design to Reduce DC Fast Charging Cost and Footprint†	Vijay Bhavaraju (Eaton)	2-96	2.67	2.83	3.33	2.83	2.85
ELT284	Ultra-low Cost, All-SiC Modular Power Converters for DC Fast Charging Equipment Connected Directly to Medium Voltage Distribution System	Srdjan Lukic (North Carolina State University)	2-99	3.50	3.50	3.50	3.33	3.48
ELT285	Development and Demonstration of Zero-Emission Technologies for Commercial Fleets (Supertruck 3)	Maarten Meijer (PACCAR)	2-103	3.38	3.25	3.50	3.25	3.31
ELT286	A Zero Emission Freight Future (SuperTruck 3)	Eric Bond (Volvo)	2-107	3.17	2.83	2.67	3.17	2.94
ELT287	Cummins High Power Density Inverter	Santhosh Krishnamoorthi (Cummins)	2-110	3.75	3.50	3.63	3.13	3.53
ELT288	Scalable Ultra Power-Dense Extended Range (SUPER) Inverter	Harsha Nanjundaswamy (Borg Warner)	2-113	3.33	3.00	3.17	3.17	3.13
ELT290	Behind-the-Meter-Storage	Matthew Keyser (National Renewable Energy Laboratory)	2-116	3.17	3.33	3.17	3.00	3.23
ELT291	Enabling Extreme Fast Charging with Energy Storage	Jonathan Kimball (Missouri University S&T)	2-119	3.83	3.67	3.50	3.33	3.65
Overall Average				**3.28**	**3.25**	**3.17**	**3.11**	**3.23**

† Denotes poster presentation.

Presentation Number: ELT158
Presentation Title: Zero-Emission Cargo Transport II, San Pedro Bay Ports Hybrid & Fuel-Cell Electric Vehicle Project
Principal Investigator: Seungbum Ha (South Coast Air Quality Management District)

Presenter

Seungbum Ha, South Coast Air Quality Management District

Reviewer Sample Size

A total of six reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

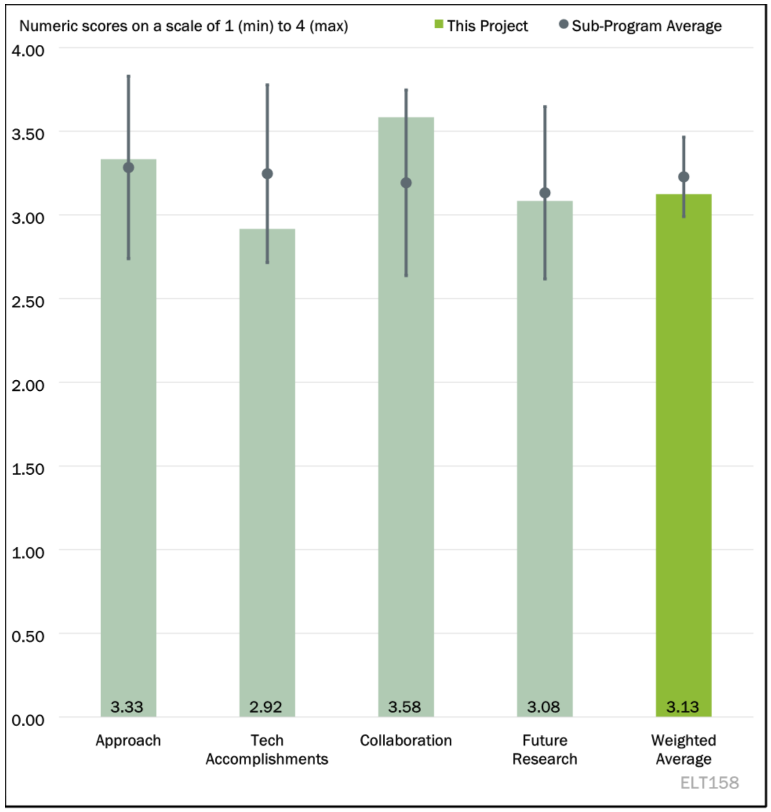

Figure 2-1 - Presentation Number: ELT158 Presentation Title: Zero-Emission Cargo Transport II, San Pedro Bay Ports Hybrid & Fuel-Cell Electric Vehicle Project Principal Investigator: Seungbum Ha (South Coast Air Quality Management District)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer stated that this 10-year project is close to completion of both goals outlined in the presentation: development of Cummins fuel cell electric vehicle (FCEV) truck, and the development of the commercialization roadmap. The reviewer added that the team members have the distinction of demonstrating the first fleet of FCEVs for drayage use in California. The reviewer mentioned that the project recognizes the barriers to adoption of this technology by drayage companies once fully developed and embraced by original equipment manufacturers (OEMs)—the most prevalent at this juncture being cost of vehicles and availability of fueling (project used portable fueling for the demonstrations). It appeared to the reviewer from the presentation that the team will work on putting the finishing touches on the commercialization roadmap during the remainder of the project period.

Reviewer 2:

The reviewer noted that this was a 2014 proposed project (9 years ago), and that it involves a variety of truck manufacturers and component suppliers who have collaborated to develop and demonstrate seven different hydrogen fuel cell and compressed natural gas (CNG) hybrid Class 8 trucks, to meet the specific duty cycle needs of the San Pedro Bay port drayage fleet in California's South Coast air basin. The reviewer indicated that the approach could be strengthened by involving additional large traditional truck OEMs but said that 9 years ago none of them were likely seriously considering fuel cell powertrains, and that project funding was not significant enough to entice their participation.

Reviewer 3:

The reviewer expressed that this project does a good job at addressing key barriers including system integration and fueling infrastructure.

Reviewer 4:

The reviewer commented that the barriers and technical challenges identified included availability and location of fueling infrastructure; costs of fuel cells, batteries, and infrastructure; and system integration to achieve safe and efficient deployment of the technologies developed. The reviewer noted that, according to the presenter, this project was initiated in December 2015 and has been funded a total of $20.5 million from all sources since then, so the timeline is reasonable to address all the barriers and challenges. The reviewer stated that the approach was to develop a series of fuel cell vehicles that would achieve increasing travel distances from 100 miles to as much as 500 miles using seven types of hybrid and fuel cell vehicles manufactured by six different OEMs. The reviewer added that this mix of vehicles and manufacturers evaluated over a 7-year period certainly allows for a well-designed project with an extensive but reasonable timeline for research and development, which is typically three to 5 years. The reviewer stated that the project efforts included an in-use demonstration and vehicle performance analysis, followed by a total cost of ownership (TCO) analysis and development of a commercialization roadmap. The reviewer confirmed that this approach supports a successful development effort from laboratory scale proof of concept to market-readiness and proof of commercialization.

Reviewer 5:

The reviewer had a hard time trying to figure out what the goals, objective, and targets for the project are. The reviewer explained that they are different for zero emission cargo transport (ZECT) I and ZECT II, and that there are so many different variations in the fuel cell trucks—platform, fuel cell capacity, battery capacity, and range—that the purpose of testing all these variables is not clear. The reviewer expressed confusion over why CNG is even included in this project because CNG is already a clearly proven and undoubtedly adopted technology. The reviewer remarked that there was no chart in the presentation on the causes of breakdown in the fuel cell or fuel system, but that the presenter was able to generally describe them. The reviewer suggested that this should be well documented if the goal is commercialization, so that all the problems in the fuel cell stacks for the different manufacturers can be fixed before they are commercialized. The reviewer added that the principal investigator needs to set thresholds for levels of acceptance, technology readiness, or market readiness and durability acceptability as well as technical specifications for what constitutes proof of product or proof of technology. The reviewer said that otherwise, everything is just smoke and mirrors.

Reviewer 6:

The reviewer remarked that this project focuses on the vehicle use case evaluation, but that the hydrogen (H_2) fueling infrastructure is still a large challenge that needs to be addressed.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer stated that vehicles were successfully put in operation and data were collected. The reviewer noted that in the eight months left in this project, the team will work on putting the finishing touches on the commercialization roadmap.

Reviewer 2:

The reviewer remarked that good progress has been made to develop and demonstrate six different zero-emission and one hybrid CNG near-zero-emission truck technologies. The reviewer added that the role of hydrogen and CNG hybrid trucks has been documented in the commercialization roadmap where, because of their quick refueling capability, they are an alternative option to battery electric trucks for routes beyond 200 miles. The reviewer expressed that California's mandate for 100% zero-emission drayage trucks by 2035 is a significant driver, and this project has provided a good platform for supporting zero-emission technology development beyond battery electric trucks. The reviewer concluded that this project has provided large strides in technology readiness level (TRL) on overall vehicle design and architecture, and that it has resulted in improvements to packaging and vehicle control strategies to increase efficiency.

Reviewer 3:

The reviewer said that having six demonstration trucks on the ground shows good progress, but more hours are needed.

Reviewer 4:

The reviewer noted that the current effort for this project is to evaluate vehicle in-service operation of a fuel cell truck used for transporting goods. The reviewer remarked that this involved deployment of the vehicles on a regularly schedule route between Long Beach, California, Los Angeles, California, and San Bernardino areas with quick fueling along the route. The reviewer added that sufficient trips were assessed to equate to a 200-mile service area. The reviewer stated that a performance analysis was conducted to compare fuel cell versus battery vehicles within ranges of 150 miles to 500 miles to detect any overall trends, and to spot days of service that would be specific to the vehicles used by the trucking company. The reviewer expressed that this in-use demonstration and vehicle performance analysis for a fuel cell HD vehicle is important to not only the trucking company but also to DOE in the areas of fuel cells and electrification, to assess how the range and refueling times of these vehicles can be improved. The reviewer remarked that this project also produced a commercialization roadmap that compared key performance metrics for diesel, compressed natural gas, hydrogen fuel cell, and battery electric HD trucks which will help define the role of hydrogen fuel cells and compressed natural gas trucks for future applications. The reviewer indicated that the data gathered for the roadmap will assist fuel cell powertrain manufactures toward their commercialization efforts for their technologies. The reviewer noted that for this evaluation, the average number of stops per day was higher for the fuel cell trucks than for conventional trucks; however, the average fuel economy was higher. The reviewer concluded that the technical progress over the past year clearly supported the project plan and produced significant findings for HD fuel cell vehicles in a real-world environment.

Reviewer 5:

The reviewer stated that without a set of established milestones, it is impossible to evaluate technical accomplishments and progress. The reviewer added that if there is a set of milestones, then the principal investigator failed to include it in his presentation.

Reviewer 6:

The reviewer declared that the status and progress are unclear of the "development of the Cummins [fuel cell electric truck] FCET." The reviewer added that the design specs are provided, and the commercialization roadmap is detailed, but the progress of the truck development is not clear. The reviewer remarked that for the six deployed trucks, there is little information provided on the results analysis of the deployment in terms of fuel consumption, efficiency, reliability (service or repair), total miles driven, range impact by load or mass, ambient temperature, road conditions or terrain, powertrain performance comparison, etc.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer commented that the presentation file references five "contractors and projects," and it is unclear if these are participants or team partners. The reviewer added that it appears at the very least, that all or most were enthusiastic participants.

Reviewer 2:

The reviewer remarked that there was a good variety of project participants, including large truck and drivetrain OEMs. The reviewer added that OEM participation could be strengthened based on today's developments; however, it is important to note that this project was proposed in 2014. The reviewer noted that National Renewable Energy Laboratory (NREL) participation for data collection and analysis adds experienced 3rd party credibility.

Reviewer 3:

The reviewer stated that the diversity of partners and funding is excellent.

Reviewer 4:

The reviewer commented that the collaboration involved a state government agency, four manufacturers of fuel cells, one manufacturer of compressed natural gas hybrid powertrains, and a national laboratory. The reviewer expressed that for the type of data needed for this project and for preparing a commercialization roadmap, this is considered to be an outstanding collaboration team.

Reviewer 5:

The reviewer liked the inclusion of Total Transportation Services, Inc. (TTSI), as an operator to demonstrate the fuel cell trucks. The reviewer has worked with TTSI before and thought they were very open-minded to trying out new technology.

Reviewer 6:

The reviewer acknowledged that several truck manufacturers are listed under "Contractors & Projects." It appeared to the reviewer that six trucks are deployed with a seventh truck under development. The reviewer suggested that the project team considers collaboration with H_2 fueling infrastructure partners to address remaining challenges.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer mentioned that this project was created with the expectation that there would be a need for future research and holds future promise for the manufacture of zero- or near-zero-emission vehicles for drayage use. The reviewer noted that Slide 16 clearly lists steps of future research.

Reviewer 2:

The reviewer expressed that future research includes continued in-use demonstration data collection, the TCO analysis, and commercialization roadmap which all seem appropriate. The reviewer suggested that input from traditional truck OEMs such as Freightliner, International, and Volvo, in addition to Kenworth and Cummins, would be important to strengthen the commercialization roadmap for fuel cell trucks beyond the perspectives of the project partners. The reviewer observed that TCO analysis should include fuel cost and driveline efficiency, as well as truck cost sensitivity analysis as the range of fuel prices depending on location can vary significantly (i.e., H_2 from \$6/kg to \$30/kg H_2 and electricity from \$0.10/kWh to \$0.50/kWh based on current hydrogen and electric truck deployments).

Reviewer 3:

The reviewer said that it will be telling if the project is able to secure regular fuel supply for this project to take steps toward market transformation.

Reviewer 4:

The reviewer remarked that proposed future research includes continuing the HD fuel cell truck demonstration to collect realistic operational data for the average vehicle miles traveled and the fuel economy, analyzing the TCO for the vehicle, fuel, and maintenance costs to also include infrastructure cost and assessment of time and weight penalties, and revising the commercialization roadmap to provide a better market development strategy and accelerate participation by original equipment manufacturers. The reviewer asserted that this is considered an excellent approach to collect and use as much information as possible in the final year of the project.

Reviewer 5:

The reviewer was unsure if this project is ready for analyzing the TCO until there is some confidence that all the problems in the fuel cell system are fixed, and until some level of technology readiness or market readiness has been achieved, and there is objective data showing that proof of product or proof of technology has been attained.

Reviewer 6:

The reviewer indicated that the portion of future research, "Collect real operation data from demonstration," would have been more effective over the prior 24 months of deployment rather than starting in the final Budget Period. The reviewer added that analysis of TCO and the commercialization roadmap are important areas of future research. The reviewer stated that H_2 fueling infrastructure should be considering for future research due to numerous challenges.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer remarked that this project most notably supports the VTO subprogram goals for Decarbonization of Off-road, Rail, Marine and Aviation (DORMA), Analysis, and Electrification. The reviewer stated that the California Air Resources Board (CARB) mandates and VTO objectives often coincide, and historically, port operations produce pollution, particularly in marginalized neighborhoods. The reviewer noted that this project represents a big step to rectify that.

Reviewer 2:

The reviewer observed that the project is relevant to the VTO Electrification subprogram as it is pushing zero-emission technology and industry envelope by demonstrating first fleet of fuel cell electric trucks in California's drayage service.

Reviewer 3:

The reviewer confirmed that it is a helpful evaluation of technologies, including electric. The reviewer added that the commercialization roadmap will be of interest to VTO and other DOE transportation programs.

Reviewer 4:

The reviewer expressed that this demonstration project fully supports the Batteries and Electrification R&D Program Office Grid and Charging Infrastructure program's mission to conduct early-stage research and development on transportation electrification technologies that enable reduced petroleum consumption by light-, medium-, and HD vehicles albeit for fuel cell vehicles and not EVs specifically.

Reviewer 5:

The reviewer wished the project could come up with some data to show that it is worthwhile paying for a fuel cell truck-tractor that costs four times that of a conventional diesel truck-tractor.

Reviewer 6:

The reviewer stated that this project supports the VTO objectives by improving HD transportation efficiency and emissions reduction.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer mentioned that the resources allocated appear sufficient and reasonable. The reviewer stated that there will undoubtedly be a need for additional resources for projects dedicated to advancing this technology.

Reviewer 2:

The reviewer noted that the significant project budget of $20 million with DOE contributing 50% was needed to develop and demonstrate seven prototype fuel cell and hybrid trucks from scratch. The reviewer added that the project completion date in 2024 will make this more than a 9-year project due to a variety of barriers faced but will provide 2 years of in-use data on each technology. The reviewer concluded that while additional budget would likely not significantly accelerate the project, it could have potentially attracted increased participation of more truck OEMs.

Reviewer 3:

The reviewer stated that costs will be challenging. The reviewer explained that while it is difficult to determine if funds will be sufficient, effort should be made to stay within cost parameters.

Reviewer 4:

The reviewer acknowledged that this project is funded $20.5 million over a 9-year period which is an average of $2.3 million per year, of which half is funded by DOE. The reviewer considered this to be sufficient funding for a demonstration project that will reap benefits for future fuel cell development.

Reviewer 5:

The reviewer had no access to costs of materials and labor to conduct a project of this nature.

Reviewer 6:

The reviewer commented that resources are sufficient for this multi-year, HD vehicle demonstration.

Presentation Number: ELT179
Presentation Title: Low Cost, High-Performance, Heavy Rare-Earth-Free 3-In-1 Electric Drive Unit
Principal Investigator: David Crecelius (American Axle and Manufacturing)

Presenter

David Crecelius, American Axle and Manufacturing

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

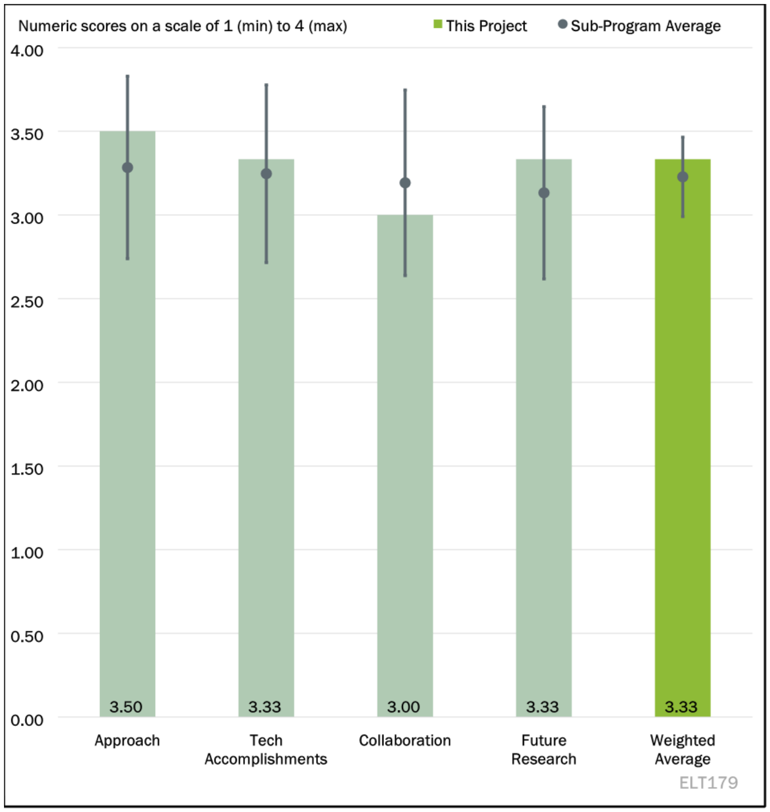

Figure 2-2 - Presentation Number: ELT179 Presentation Title: Low Cost, High-Performance, Heavy Rare-Earth-Free 3-In-1 Electric Drive Unit Principal Investigator: David Crecelius (American Axle and Manufacturing)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer said that the technical barriers are nicely documented and transparently addressed.

Reviewer 2:

The reviewer remarked that American Axle and Manufacturing (AAM) has done an outstanding job addressing the technical barriers. The reviewer added that AAM has been very professional in their approach and execution of this project.

Reviewer 3:

The reviewer indicated that the core idea of a high-speed induction motor with copper rotor bars is not novel. The reviewer added that the mass, volume, and efficiency of the gearbox should be factored in the predicted system performance. The reviewer noted that some detailed cost comparison of the induction motor with copper rotor bars versus a permanent magnet (PM) counterpart should be provided.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer indicated that the project appears to be on track with all the promised deliverables met.

Reviewer 2:

The reviewer stated that AAM has made excellent technical progress. The reviewer highlighted that when they had difficulty with the silver sintering, they quickly moved to copper sintering.

Reviewer 3:

The reviewer noted that there is no thermal analysis or measurements presented to show the predicted system thermal performance. The reviewer remarked that no mechanical analysis or rotor spin test was presented to prove the structural integrity of the high-speed motor. The reviewer suggested that more information and analysis regarding the integration details of the motor and inverter should be provided. The reviewer asked if, with the inverter tightly integrated with the motor, there are any vibration or thermal issues expected.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer stated that clear leadership is evident, which drives results. The reviewer added that in other projects some collaborators appear to be pro-forma, without a major contribution, so the reviewer did not mind the lack of laboratories of universities as collaborators.

Reviewer 2:

The reviewer confirmed that AAM appears to have assembled an excellent team, each member with their own strengths.

Reviewer 3:

It seemed to the reviewer that the main bulk of the project is really done within the primary recipient.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer stated that the project is on track, clearly defined, and documented. The reviewer was looking forward to next year.

Reviewer 2:

The reviewer noted that future work is directly in line with the original plan and is very well executed.

Reviewer 3:

The reviewer remarked that ultimately testing the full system will be helpful, but some of the intermediate analysis and testing referred to should be considered.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer noted that in the Electrification (subprogram), this is one of the top projects.

Reviewer 2:

The reviewer remarked that the “Relevance” slide in this presentation is one of the best from the Annual Merit Review (AMR) and stressed that it was outstanding.

Reviewer 3:

The reviewer expressed that the project tries to eliminate RE material and to come up with a lower cost, more compact and integrated electric drivetrain.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that the cost appears to be sufficient and well tracked.

Reviewer 2:

The reviewer noted that the resources for this project have been well spent.

Reviewer 3:

The reviewer affirmed that the resources are sufficient for the scope.

Presentation Number: ELT197
Presentation Title: High Power and Dynamic Wireless Charging of Electric Vehicles
Principal Investigator: Veda Galigekere (Oak Ridge National Laboratory)

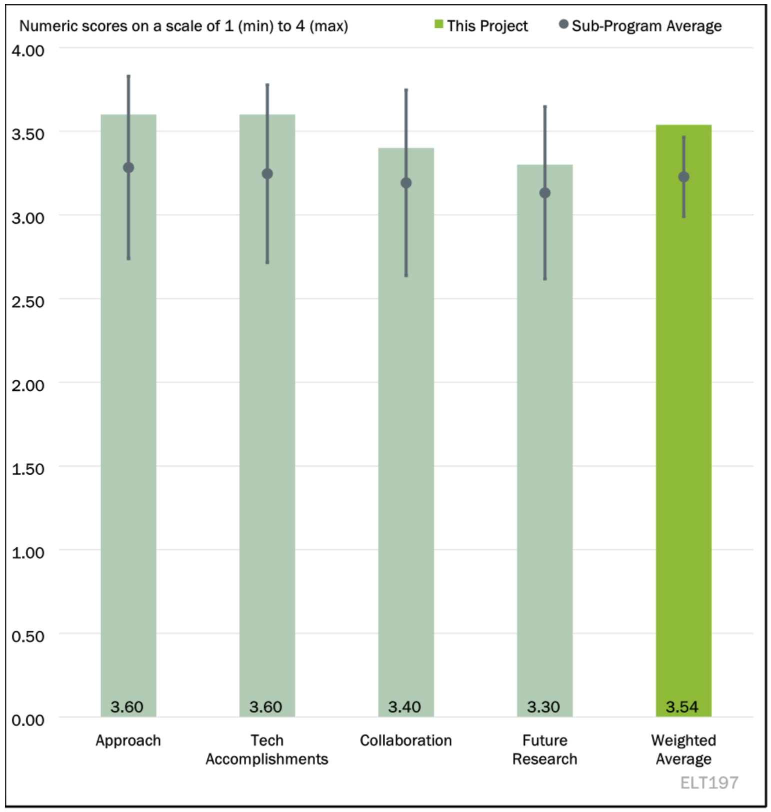

Figure 2-3 - Presentation Number: ELT197 Presentation Title: High Power and Dynamic Wireless Charging of Electric Vehicles Principal Investigator: Veda Galigekere (Oak Ridge National Laboratory)

Presenter

Veda Galigekere, Oak Ridge National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 80% of reviewers felt that the resources were sufficient, 20% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer observed that this Oak Ridge National Laboratory (ORNL) led project's workflow is logical and as per engineering practices because analytical and simulation works feed data requirements for hardware development, followed by laboratory validation of the 200 kW dynamic wireless power transfer (DWPT) system, which will lead to real world validation at 200 kW level. The reviewer added that the project report has included some pictures of the parts that would be required in the development of a prototype of the proposed DWPT.

Reviewer 2:

The reviewer noted that the project targets full-scale demonstrations of wireless charging technology. The reviewer remarked that the program also includes laboratory and road validation of the technology, including intermediate check points and design reviews. The reviewer concluded that the approach is rational and sound.

Reviewer 3:

The reviewer commented that the approach is excellent—starting with laboratory development and testing and then moving to the demonstration of the system installed in a roadway with vehicle testing. The reviewer noted that various vehicle speeds are also considered which applies to match the application into production vehicles with the power level required.

Reviewer 4:

The reviewer remarked that three challenges were identified as barriers to high power and dynamic wireless charging of EVs: power density, efficiency; and controllability. Regarding power density, the reviewer referenced development of a compact vehicle coil and power electronics assembly which can receive 200 kW power dynamically. Concerning efficiency, the reviewer noted achieving 90% efficiency in a vehicle integrated dynamic wireless charging system. And with controllability the reviewer referenced identifying and implementing a control and communication system which can perform wide range power regulation without compromising efficiency or power density. The reviewer mentioned that the approach to complete the proof-of-concept validation included analytical and simulation studies; hardware design and development; laboratory validation of 200 kW dynamic wireless power transfer; and real-world validation of 200 kW DWPT.

Reviewer 5:

The reviewer observed that the project is well-designed covering all aspects of dynamic charging in light-duty and HD vehicles. The reviewer added that hardware development along with laboratory and real-world validation captures all the aspects of dynamic charging. The reviewer said that dynamic inductive charging is operational and will be used to perform controlled dynamic charging tests to optimize control and efficiency.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer stated that baseline performance was established in stationary mode. The reviewer remarked that the 200 kW DWPT system with receiver coil was mounted on a Hyundai Kona. The reviewer observed that the project team validated power transfer capability in dynamic mode, including capturing waveforms to assess peak magnitude of the output power during DWPT operating mode of the system. The reviewer said that a list test of transmitter coil buried in concrete slab was carried out, along with a preliminary review of structural design. The reviewer noted that the status of high power DWPT system validation in the American Center for Mobility (ACM) is described in the project's AMR report, the DWPT data acquisition system was completed, and the operational functionality was verified.

Reviewer 2:

The reviewer noted that significant progress has been made on the program. The reviewer stated that design and hardware validation has been demonstrated for laboratory conditions. The reviewer reported that ongoing work seeks to validate at relevant driving speeds and for on-road conditions. The reviewer indicated that several milestones listed for 2022 were identified as planned or in progress, but questioned if perhaps there was an error in the dates as these efforts are now ongoing. If not, then the reviewer concluded that the project is delayed by approximately 1 year.

Reviewer 3:

The reviewer stated that the laboratory tests are conducted at reasonable speeds to capture lower vehicle speeds, and that track testing will capture the higher speeds projected for the system.

Reviewer 4:

The reviewer observed that the project team members validated stationary power transfer at an efficiency of 93.7% with no thermal hotspots. The reviewer added that validation of power transfer capability in dynamic mode was then completed at 6 meters per second (13 miles per hour). The reviewer added that the test rig has the capability to test up to 9 m/s (20 mph) over the track length of 18 meters. The reviewer noted that the in-ground transmitter structure was assessed, and it was determined that the surface cracks which occurred during setting and curing did not propagate, and that no buckling or deflections were observed. The reviewer said that DWPT data acquisition system for ground side and vehicle side measurements were completed, and the operational functionality was verified using a production EV with a Nissan Leaf. The reviewer indicated that a final demonstration is still pending, and real-world validation is ongoing.

Reviewer 5:

The reviewer noted that the project team completed high-level cost and feasibility studies and identified the architecture suitable for 200 kW DWPT. The reviewer added that the team completed design, development, and laboratory benchtop validation of primary and secondary side power electronics design of 200 kW DWPT system. The reviewer indicated that the team completed design, development, and validation of DWPT coils and tuning network. The reviewer observed that the team is identifying and developing active and passive electromagnetic field shielding solutions for 200 kW DWPT system. The reviewer stated that the team analyzed feasibility of large-scale deployment of DWPT system on primary roadways in Atlanta; developed E-Roads Tool for analyzing large-scale deployment of DWPT system on roadways; and completed laboratory validation of 200 kW DWPT system.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer noted that an excellent collaboration exists in execution of project activities.

Reviewer 2:

The reviewer stated that the majority of work is centralized at ORNL, with input and support from other partners. The reviewer added that engagement external to the laboratory is beginning.

Reviewer 3:

The reviewer indicated that system approaches are excellent with support from other laboratories, and that these are complementing the project with electromagnetic compatibility/electromagnetic fields (EMC/EMF) evaluation and multiple vehicle designs.

Reviewer 4:

The reviewer observed a good balance between national laboratory participation (ORNL, Idaho National Laboratory [INL], NREL), vehicle OEM (Hyundai Kia American Technical Center), test facility (American Center for Mobility) and a university research institute (Virginia Tech Transportation Institute). The reviewer added that this project will impact utilities, and a national utility organization should be added to the team as this system moves toward commercialization.

Reviewer 5:

The reviewer acknowledged that Hyundai America Technical Center, Inc., (HATCI) is providing an EV, as well as support and guidance on vehicle-integration of DWPT system. The reviewer added that ACM is providing infrastructure and physical proving grounds for validation of 200 kW DWPT system. The reviewer said that Virginia Tech Transportation Institute (VTTI) is providing guidance and support to develop roadworthy DWPT coils. The reviewer concluded that all of the collaboration was well planned and executed and produced valid results.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer stated that the project report included future research task and topics, which are relevant and appropriate.

Reviewer 2:

The reviewer mentioned that the project work is nearing completion. The reviewer noted that future work suggestions include developing specifications documents as well as lessons learned from the project that may help inform both future research at the system level, but also the component and even subcomponent level. The reviewer asked what the key limiting factors and technologies currently are.

Reviewer 3:

The reviewer observed that alternatives of primary coil could be useful to reduce installing magnetics in the roadways, and that higher power may also be offered for larger vehicle applications.

Reviewer 4:

The reviewer said that this project is coming to an end. The reviewer indicated that the characteristics that will be assessed through planned future research include: efficiency, power, and energy profiles; safety misalignment tolerance; thermal profiles; emissions and shielding; interoperability; and environmental factors. The reviewer added that the high power DWPT system validation is planned for demonstration at 55 mph in the summer of 2023 at the ACM, and that integrating the passive electromagnetic-field shielding solution developed by INL with the 200 kW DWPT system developed by ORNL is also planned to be completed.

Reviewer 5:

The reviewer indicated that the project validates performance and functionality of 200 kW DWPT system, and analyzes the power transfer characteristics including: efficiency, power, and energy profiles; safety misalignment tolerance; thermal profiles; emissions and shielding; interoperability; and environmental factors.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer stated that this project is relevant to the VTO electrification subprogram and will accelerate adoption of EVs as battery size could go down and cost target could be met for many Americans.

Reviewer 2:

The reviewer noted that the project is highly relevant to future EV charging infrastructure.

Reviewer 3:

The reviewer observed that vehicles using dynamic wireless charging offer a means to provide the propulsion energy and some recharging of the high voltage (HV) battery while traveling. The reviewer explained that this offers opportunity for lower capacity HV batteries and less time and energy for charging at alternating current (AC) and direct current (DC) charging locations.

Reviewer 4:

The reviewer said that the project is directly relevant to the VTO Materials subprogram objectives.

Reviewer 5:

The reviewer commented that validating high power and dynamic wireless charging of EVs is essential to move transportation to zero tail pipe emission technologies. The reviewer added that charging locations and time to charge is a very large issue not resolved in EV deployments worldwide.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer noted that the project has necessary resources and research funds.

Reviewer 2:

The reviewer stated that overall, the project seems to be successful, but the challenge and complexity of the problem being addressed could benefit from additional resources in this area.

Reviewer 3:

The reviewer observed that this project has managed resources of other laboratories, vehicles, and test sites to maintain the full spectrum of effort required.

Reviewer 4:

The reviewer indicated that the resources appear to be sufficient to achieve the stated goals of the project.

Reviewer 5:

The reviewer affirmed that the project has all the resources required to this point. The reviewer said that any further research will require end user transportation professionals as part of the team. The reviewer added that these end users will need to be fleets with internal engineering capability to ensure the project is on pace to be business friendly, cost effective, and reliable to industry.

Presentation Number: ELT208
Presentation Title: Highly Integrated Power Module
Principal Investigator: Lincoln Xue (Oak Ridge National Laboratory)

Presenter

Lincoln Xue, Oak Ridge National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

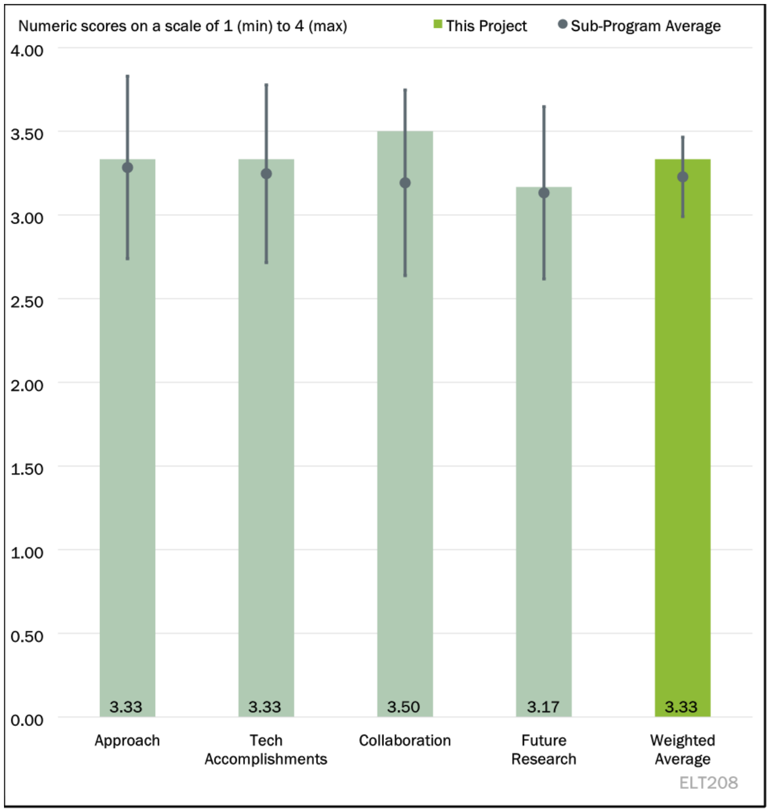

Figure 2-4 - Presentation Number: ELT208 Presentation Title: Highly Integrated Power Module Principal Investigator: Lincoln Xue (Oak Ridge National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer stated that project activities are for automated power module design which uses a new analysis method that is a computationally efficient method for optimized layout including base-place and cold plate associated with power module of power converters. The reviewer added that having many designs and then down selecting the optimal design is an appropriate approach for the power module design.

Reviewer 2:

The reviewer remarked that the proposed work combines targeted experiments with modeling and optimization. The reviewer said that the work plan is sound and clearly aligns with targeted improvements to technical challenges relevant for highly integrated power modules, with emphasis on thermal performance. The reviewer recommended that additional work should be placed upon isolation requirements.

Reviewer 3:

The reviewer mentioned that there was a design and prototype of organic direct bonded copper (ODBC) based power modules with integrated gate driver and cooling to enhance thermal performance.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer noted that key activities that are completed by the project team and are likely to set this project for the successful completion include and details of work underwent for these tasks is outlined in the project report. The reviewer explained that the team designed a silicone carbide (SiC) power module based on a thermal pyritic graphite (TPG)-ODBC substrate, integrated gate driver, and heat sink; prototyped the ODBC-based power module; evaluated electrical performance of the Cu-ODBC power module; fabricated multiple substrate samples for breakdown evaluation; completed thermal evaluation with the Cu-ODBC power module; developed a simulation framework of indirect and direct substrate cooling for wide bandgap (WBG) power modules; designed high-performance direct cooling of power modules based on optimized jet impingement structures; completed thermal-mechanical analysis on direct substrate cooling; invented a new heat sink geometry generation method; generated genetic algorithm optimized heat sink designs using a multi-profile merging method; simulated the thermal performance of the selected new heat sink design; and discovered mechanisms of better performance for the multi-profile merging method.

Reviewer 2:

The reviewer remarked that the project has made significant progress towards the targeted goals, and that there are currently no indications of a deficiency in technical performance.

Reviewer 3:

The reviewer noted the prototyping and evaluation of electrical performance.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer observed that a strong collaboration exists in execution of project activities.

Reviewer 2:

The reviewer remarked that the work appears largely centralized at ORNL. The reviewer added that if substantive contributions are being made by partners, it is not clearly represented within the peer review slides. The reviewer suggested clearly identifying partner contributions where appropriate in future updates.

Reviewer 3:

The reviewer noted a good combination of partners that includes laboratories, industry as well as academic research.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer stated that the project team has outlined future research. The reviewer observed that it would be nice if material saving, and carbon footprint reduction are also assessed due to technique developed in this project. The reviewer added that the profiled heatsink will require a far complex fabrication process, and the aspect of how that would impact adoption of such a heat sink in real world applications needs some research efforts.

Reviewer 2:

The reviewer noted that isolation should be a primary consideration for future work. The reviewer added that the future work should clearly focus on practical embodiments of the proposed advanced cooling designs which are both reproducible and scalable in terms of manufacturability.

Reviewer 3:

The reviewer remarked system integration and evaluation.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer stated that this project is relevant to VTO sub-program in electrification area and could fulfill keystone projects' objectives.

Reviewer 2:

The reviewer said that this program has clear relevance.

Reviewer 3:

The reviewer noted that the project is relevant to all defined targets: Power density at 100 kW/L; cost at $2.70/kW; peak efficiency at greater than 97%; and reliability at 300,000 mile lifetime or fifteen years.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer noted that the project has necessary resources and research funds.

Reviewer 2:

The reviewer said that resources appear to be appropriate for the proposed work scope.

Reviewer 3:

The reviewer remarked that the design for manufacturing has a great deal of input by industry yet to be observed.

Presentation Number: ELT209
Presentation Title: High-Voltage, High-Power Density Traction-Drive Inverter
Principal Investigator: Gui-Jia Su (Oak Ridge National Laboratory)

Presenter

Gui-Jia Su, Oak Ridge National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

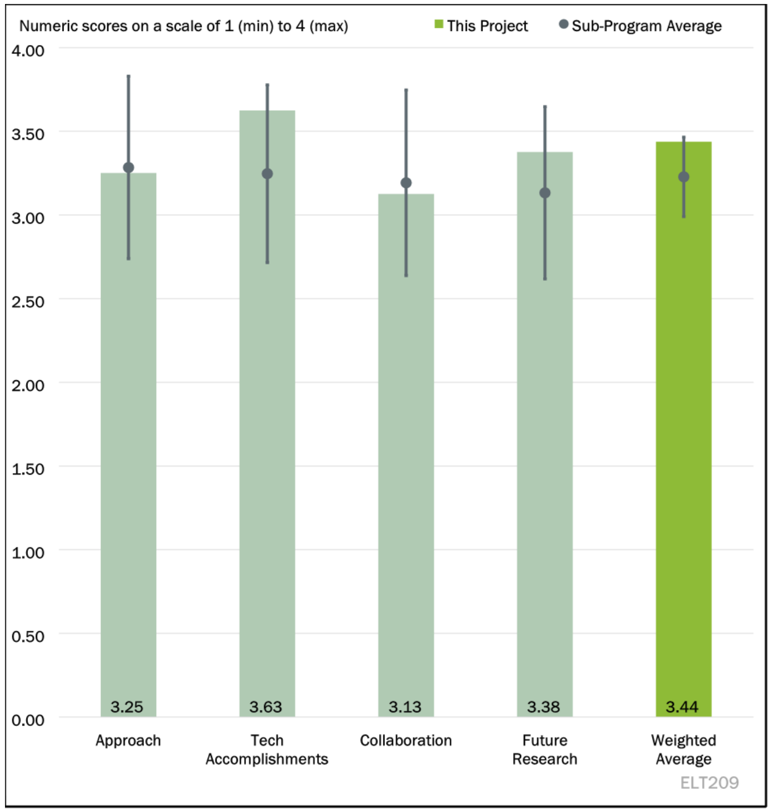

Figure 2-5 - Presentation Number: ELT209 Presentation Title: High-Voltage, High-Power Density Traction-Drive Inverter Principal Investigator: Gui-Jia Su (Oak Ridge National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer said that the project addresses a segmented inverter, which has the potential to significantly decrease capacitor ripple current for improved reliability and performance. The reviewer noted that the project team is using advanced devices and packaging to enable higher DC bus voltage. The reviewer’s only minor critique is that the need for an asymmetrical six-phase inverter—with 30^{o} phase shift—is not fully explained. The reviewer added that the sophisticated packaging and overall architecture are the focus of the project and are appropriate to address the objectives.

Reviewer 2:

The reviewer stated that the approach to the design of the segmented inverter is interesting and different and seems technically capable. The reviewer noted that the assessment of reliability and practicality in terms of cost—both related to total amount of semiconductor needed for the segmented circuit topology—seems lacking overall. The reviewer added that the approach would benefit greatly from a techno-economic analysis that considered these factors and made an assessment of the cost and reliability impacts. The reviewer shared, as a general comment, that the cooling solution and power card-like structure plus module packaging is very similar to Denso’s design, regardless of the heat sink fin optimization and three-dimensional (3D) printing of manifold, so the reviewer questioned if the novelty really is just the segmented topology or some other aspect.

Reviewer 3:

The reviewer noted the well-defined inverter architecture to reduce capacitor requirement, as well as the operating bus voltage of more than 800V.

Reviewer 4:

The reviewer remarked that the project does address the issue of reducing the space claim of large capacitances and also maintains high efficiency. The reviewer added that it would be interesting to see a trade-off between this approach and using higher switching frequency to achieve the same goals. The reviewer explained that while the general trends with the two approaches are clear, it would be good to quantify these differences. The reviewer stated that different hat sink designs are interesting, but it is unclear what impact the manufacturing processes would have for volume production.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer observed that the team has made excellent progress on two different packaging approaches. The reviewer noted that the team has developed an inverter control system; completed a 100 kW inverter with excellent efficiency; has a 200 kW inverter designed, including an optimized heat sink, as well as parts of a Gen-2 200 kW system. The reviewer suggested that the team investigates the suitability of the thermistor isolation, as its physical separation may be adequate for prototypes but not for products.

Reviewer 2:

The reviewer noted that significant accomplishments are demonstrated related to the 100 kW and 200 kW inverter designs, fabrication, and test, and offered that testing at higher power levels should be accelerated.

Reviewer 3:

The reviewer remarked that the efficiency at 100 kW load for Gen 1 inverter design has not been reported.

Reviewer 4:

The reviewer declared that while the Gen 1 appears to have fallen short of the power density goals, the Gen 2 inverter appears to be on track to meet the goals. The reviewer added that a significant reduction in ripple current has also been shown. The reviewer said that it is also good that, unlike some other projects, this project is working with a DC bus voltage of 800V instead of 400V, since given the power of most EVs that are being sold/will be sold in the United State, and due to fast charge requirements, 400V DC bus will likely be phased out in favor of 800V.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer expressed concern that relates to the two apparently separate inverter developments taking place at Virginia Tech and the University of Arkansas, as they have similar goals and approaches and seem to be more in competition than in collaboration.

Reviewer 2:

The reviewer observed that there seems to be a lot of collaboration happening in the presented materials, and the table clarifies who is doing what, but it would benefit reviewers to highlight collaborator efforts on appropriate slides throughout.

Reviewer 3:

The reviewer stated that while there has been excellent cooperation between the University of Arkansas, Virginia Tech, and Oak Ridge, this project could have benefited from the involvement of an OEM or supplier—this would have helped ensure that at the conclusion of the project, there is a greater chance of this technology being implemented into production. The reviewer added that Slide 7 lists roles for Virginia Tech, University of Arkansas, and ORNL, but it is unclear throughout the presentation, what the role of NREL is in this project. The reviewer noted that it is clear that NREL has developed considerable expertise in thermal management, but it is unclear how or if that is being used in this project.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer observed that the team proposes to finish testing the Virginia Tech design and the Gen-1 University of Arkansas design, as well as to complete the design of a Gen-2 University of Arkansas inverter. The reviewer remarked that it is unclear whether there will be a full "Gen-2" Virginia Tech design or just some improvements to the Gen-1.

Reviewer 2:

The reviewer was curious to see more information on parasitic losses of the module design and efficiency over the expected full power range.

Reviewer 3:

The reviewer declared that future plans are clearly laid out and make sense, given the outcome of the project up until now.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer noted that the project directly addresses inverter power density objectives.

Reviewer 2:

The reviewer mentioned that the project is highly relevant to electrified powertrain R&D.

Reviewer 3:

The reviewer observed that the project is relevant to all defined targets: power density at 100 kW/L; cost at $2.70/kW; peak efficiency at greater than 97%; and reliability at 300,000-mile lifetime or fifteen years.

Reviewer 4:

The reviewer stated that reducing the size or increasing the power density of every component is very important to the OEMs and suppliers, since space is always a premium. The reviewer added that with the OEMs constantly trying to increase the range, battery packs keep getting bigger and require more real estate. The reviewer commented that any space saving that can be offered up by any other components would always be welcome.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer observed that there are no obvious deficiencies, and the work seems to be scaled properly to the resources available.

Reviewer 2:

The reviewer stated that the resources are sufficient.

Reviewer 3:

The reviewer mentioned that the resources are sufficient.

Presentation Number: ELT211
Presentation Title: Power Electronics Thermal Management
Principal Investigator: Gilbert Moreno (National Renewable Energy Laboratory)

Presenter

Gilbert Moreno, National Renewable Energy Laboratory

Reviewer Sample Size

A total of six reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

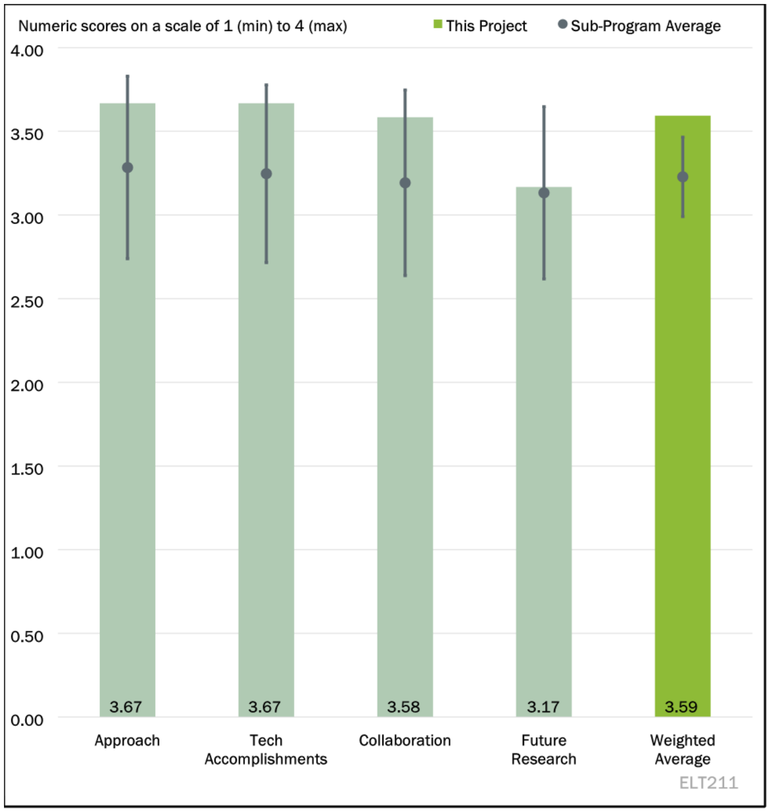

Figure 2-6 - Presentation Number: ELT211 Presentation Title: Power Electronics Thermal Management Principal Investigator: Gilbert Moreno (National Renewable Energy Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer stated that this project includes both thermal cycling and electrical performance testing to ensure that the new cooling approach effectively improves thermal performance without compromising electrical behavior.

Reviewer 2:

The reviewer noted that the comparison between conventional direct bonded copper (DBC) base power module and dielectric fluid cooled power module is an appropriate way to establish performance target for enhance cooling potentially possible with the dielectric fluid used as coolant. The reviewer added that the project principal investigator (PI) then addressed concerns associated with dielectric fluid-based colling of the power module. The reviewer noted that dialectic fluid cooled power module attempts to eliminate failure prone components such as ceramic layers while resorting to double side cooling to realize improved performance. The reviewer explained that over the temperature evaluation of the effectiveness of the dielectric fluid-based cooling should be carried out by project investigators.

Reviewer 3:

The reviewer stated that the project aims to improve the thermal management of power electronic converters to increase power density and reliability. The reviewer added that the power electronic converters can be made smaller if advanced cooling concepts can be applied. The reviewer observed that this project aligns with achieving the year 2025 DOE 100 kW/L power density target. The reviewer noted that the approach is well-defined, and initial studies are promising for thoroughly evaluating this novel cooling scheme using a dielectric fluid with advanced packaging.

Reviewer 4:

The reviewer commented that the module cooling solution approach seems well thought out and designed. The reviewer added that both single phase and two-phase solutions have been proposed, and that the timeline seems reasonable and achievable.

Reviewer 5:

The reviewer liked that the approach specifically addresses concerns one might have with the use of dielectric fluids. The reviewer stated that the timing seems reasonable given the funding level. The reviewer would prefer to see this type of work happening at a quicker pace though.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer noted that the project team has achieved excellent thermal performance and good model agreement. The reviewer observed that the team has provided useful comparative evaluation of several fluids to identify their relative advantages. The reviewer added that the team has started long-term thermal/electrical testing. The reviewer highlighted that the collaboration with the Georgia Tech team for two-phase cooling is a little unclear, and that presumably this is more fully explored in a separate project.

Reviewer 2:

The reviewer said that the SiC-based module fabricated and inserted in housing enabled dielectric fluid-based cooling and heat exchanger system followed by demonstration of cooling system. The reviewer stated that the test verification revealed that thermal performance evaluated by simulation and experimentation revealed similar level of capability of proposed design for the dielectric fluid-based power module cooling. The reviewer observed that the relation between fluid flow rate and power needed for dielectric fluid pumping is found as expected. The reviewer stated that the experimental apparatus was fabricated to evaluate long-term reliability of the dielectric fluid and associated heat exchanger. The reviewer said that the test apparatus realized through collaborative activities with Georgia Tech is included in the AMR report and phase change cooling has been experimented.

Reviewer 3:

The reviewer noted that the project aims to eliminate thermally resistive and failure-prone ceramic components in today’s semiconductor packages. The reviewer noted that the project targets to reduce package resistance by 18%–43% by introducing a new concept. The reviewer explained that to achieve this goal, the packaging uses single-phase heat transfer. The reviewer observed that it is nice to see that project developed both single- and double-side-cooled configurations. The reviewer added that the team fabricated silicon-carbide power modules that use dielectric fluids for cooling, and that the project conducted experiments to measure the junction-to-fluid thermal resistance and pumping power. The reviewer remarked that the results are promising, and significant benefits are achieved, as illustrated in the results section of the presentation.

Reviewer 4:

The reviewer noted that the technical accomplishments are substantial and well-demonstrated through well-coordinated efforts with collaborators. The reviewer added that the high cooling performance with moderate pressure drop is achieved.

Reviewer 5:

The reviewer stated that the electric evaluation is essential to fully assess and agree to thermal evaluation benefits.

Reviewer 6:

The reviewer expressed that it was great to see the power module test setup together and under test, and that having a defined test process is excellent. The reviewer added that measurements of thermal resistance to pumping power is a key factor to gain an understanding of the performance of this method. The reviewer offered that developing an understanding of material compatibility and dielectric changes over time are critical.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer observed that it appears that the two-phase cooling subproject is integrated at the level of personnel, with a somewhat nebulous technical connection. The reviewer remarked that other team members are more clearly integrated.

Reviewer 2:

The reviewer stated that the project team has strong collaborative activities underway in a team makeup that has NREL, universities and industries.

Reviewer 3:

The reviewer mentioned that the project collaborates with Georgia Tech, Infineum, Oak Ridge National Laboratory, and the State University New York (SUNY) Polytechnic Institute. The reviewer said that it is good to see that project is collaborating with Georgia Tech to evaluate two-phase cooling strategies, and NREL designed and fabricated the experimental apparatus used for the experimental demonstration.

Reviewer 4:

The reviewer notes that the collaboration efforts were clear and substantial in the presentation.

Reviewer 5:

The reviewer remarked that it is to date and as planned.

Reviewer 6:

The reviewer observed that the number of collaboration events seems good, but it wasn’t clear how much effort was being put into it.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer said that the team has initiated long-term testing, which by its nature will extend over the future budget periods. The reviewer stated that the team has identified some of the important challenges and ways to address them; however, the team has not really addressed the issue of contamination. The reviewer remarked that the team also identifies industry adoption as a barrier without a plan to address it.

Reviewer 2:

The reviewer commented that the project team has outlined future research. The reviewer suggested that the project team must evaluate over the temperature evaluation of the effectiveness of the dielectric fluid-based cooling system and heat exchanger including phase change cooling system.

Reviewer 3:

The reviewer observed that future work is well-defined. The reviewer added that the team plans to perform electrical simulations to evaluate the effect of the dielectric fluid on electrical performance and perform power cycling on the ceramic-free module to evaluate for reliability. The reviewer recommended that experimental results be compared with analytical and simulation results in the future. The reviewer noted that a comparison with today's technology, where the ceramic layer is used, is done.

Reviewer 4:

The reviewer declared that the specific study point for the electrical simulations relative to the cooling fluid dielectric properties was not clear. The reviewer asked what will be studied and how, especially numerically. The reviewer added that the statement, "collaborate with Georgia Tech to develop the advanced cooling technologies," is generic and asked what exactly will be done.

Reviewer 5:

The reviewer mentioned that electric and reliability evaluation is essential.

Reviewer 6:

The reviewer thought it is an appropriate plan given the level of funding.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer stated that the project addresses an alternative cooling strategy that would support an increase in power density for inverters.

Reviewer 2:

The reviewer noted that this project is relevant to VTO sub-program in electrification area and aligns with the keystone project objective for 100 kW/L power-dense inverter.

Reviewer 3:

The reviewer stated that DOE year 2025 targets 100 kW/L for power electronics, and that the project tries to achieve this target by contributing to the advanced cooling of power electronics using dielectric fluids and novel packaging techniques for semiconductor power switches.

Reviewer 4:

The reviewer declared that this project is highly relevant to the cooling of high heat flux semiconductor devices for future power conversion systems.

Reviewer 5:

The reviewer said it is fully relevant.

Reviewer 6:

The reviewer remarked that how to thermally manage high density power electronics is a key area for the program.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer observed that the work appears to be scaled appropriately to the resources available.

Reviewer 2:

The reviewer noted that the project has necessary resources and research funds.

Reviewer 3:

The reviewer declared that the resources are adequate.

Reviewer 4:

The reviewer thought that the resources appear to be sufficient.

Reviewer 5:

The reviewer affirmed that the next phase will reflect the effect of needed strong collaboration between thermal and electrical teams.

Reviewer 6:

The reviewer remarked that based on the level of funding available, the project has adequate resources, but things really should be happening at a faster pace if they are going to help industry compete.

Presentation Number: ELT215
Presentation Title: Develop fine-grain Rare Earth permanent magnet with high coercivity at high temperature AND cost-effective manufacturing process for high performance soft magnetic materials in thin sheet form
Principal Investigator: Iver Anderson (Ames Laboratory)

Presenter

Iver Anderson, Ames Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 80% of reviewers felt that the resources were sufficient, 20% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

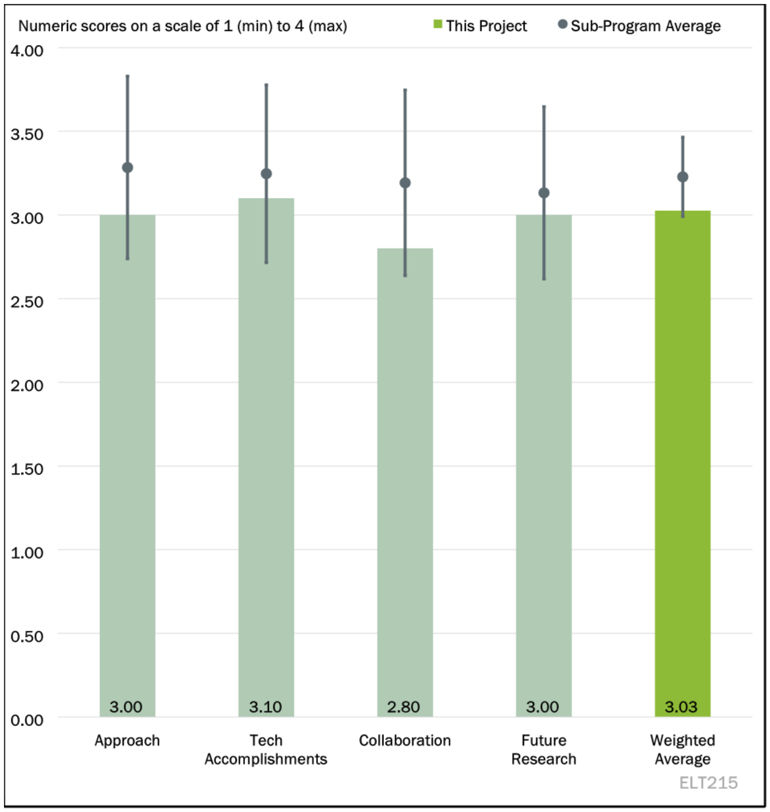

Figure 2-7 - Presentation Number: ELT215 Presentation Title: Develop fine-grain Rare Earth permanent magnet with high coercivity at high temperature AND cost-effective manufacturing process for high performance soft magnetic materials in thin sheet form Principal Investigator: Iver Anderson (Ames Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer stated that the approach to perform the work is rational and shows a progression from early concepts to improved processing strategies and material chemistries. The reviewer said that sufficient time is allocated for iterative improvements considering new learnings and outcomes of the project work activities.

Reviewer 2:

The reviewer mentioned that the project is about developing better and cheaper magnets without using heavy rare earth elements. The reviewer explained that the project addresses the technical barriers of PMs being expensive and heavy rare earth (HRE) elements being scarce and their price volatility. The reviewer added that it also captures that non-rare earth PM electric motor has low power density, so a better solution is needed. The reviewer concluded that the project aims to achieve advanced processing to achieve high-energy PMs without scarce/costly HRE to achieve high-power density motors.

Reviewer 3:

The reviewer noted that this project is now in year five of a 6-year program; yet no data was shared regarding the progress towards the two specific goals of the project: drive motor power density and cost. The reviewer urged more focus be placed on these goals during the 2024 AMR.

Reviewer 4:

The reviewer declared that the project correctly identifies the technical barriers for permanent magnet and soft magnetic materials for advanced electric machines. The reviewer said that the plan to address these barriers could be improved if issues pertaining to production at full-scale could be included in the experimental plan. The reviewer asked that, for example, for passivation of permanent magnets, what degree of oxidation is acceptable in full-scale magnet manufacturing. The reviewer also asked what level of oxygen and dew point control are used in NdFeB magnet manufacturing are used today, and how much does the nitrogen trifluoride (NF_3) passivation method relax those requirements. The reviewer inquired that for the 6.5% silicon steel, what is the thickness and width, and annual production tonnage of 3% silicon steel produced today, and how close to this production capacity can melt-spun 6.5% Si steel achieve.

Reviewer 5:

The reviewer said it is not clear if successful how these materials will compare in terms of properties and cost to some of the commercially available materials especially permanent magnets that do not include heavy rare-earth materials.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer remarked that project progress has been significant and according to the project plan. The reviewer noted no major deficiencies, and several technical challenges identified, like oxidation of powders in permanent magnets and castability of soft magnetic alloys, have been overcome to some extent through modifications to material chemistries and/or processing techniques. The reviewer stated that work still remains to understand how to manufacture required powder feedstock for the permanent magnet activities and further optimization of castability and thickness is required for the soft magnetic alloys.

Reviewer 2:

The reviewer said that the project accomplished its primary goals, including designing and building a passivation powder collection chamber, carrying out trial runs and establishing a relationship among passivation parameters, powder oxidation, and powder magnetization, and investigating the effect of the passivation layer on sintering density and building magnet properties. The reviewer commented that the results have been well explained, figures were shown, and successes and challenges are well explained.

Reviewer 3:

The reviewer observed that there is a good approach of using three unique methods of milling the magnetic materials. The reviewer would have liked to hear more about the next generation of soft materials on Slide 20, but the presenter ran out of time. The reviewer offered that the project assumptions should be clearer, perhaps on a separate slide.

Reviewer 4:

The reviewer mentioned that the technical accomplishments have been good relative to the project plan. The reviewer remarked that the inability to attempt multi-jet jet milling due to equipment availability appears to have required a pivot to laboratory-scale milling methods which may not adequately approximate the jet milling process. The reviewer noted that the melt spun 6.5% silicon steel has completed proof-of-concept experiments, but the applicability to electric machine technology remains undemonstrated. The reviewer added that it is not clear if the reduction in watt loss at 1 kHz on Slide 18 is due to the higher resistivity of the melt spun 6.5% silicon steel or the thinner thickness of the meld spun material.

Reviewer 5:

The reviewer highlighted that it is important to include some information showing the expected motor performance using current or projected material properties.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer stated that the work appears to be largely independent of other project activities, with limited input and guidance on necessary material properties.

Reviewer 2:

The reviewer noted that the project collaborates excellently with national laboratories (ORNL, NREL, and Sandia) and other universities. The reviewer commented that there is a productive relationship, and collaboration results are clearly shown.

Reviewer 3:

The reviewer did not see any citations for Sandia or the university partners, but there was a good collaboration with ORNL and NREL.

Reviewer 4:

The reviewer remarked that collaboration with industry could be substantially improved. The reviewer explained that there are now several domestic companies attempting to establish NdFeB manufacturing facilities, like MP Materials, Noveon, GKN Hoeganaes, and Advanced Magnet Laboratory, and could provide input on the NF_3 passivation method. The reviewer added that domestic steel manufacturers like Cleveland-Cliffs formerly AK Steel, ATI Specialty Materials, and Carpenter Technology Corporation, could provide input on the scalability of the melt spun 6.5% silicon steel material.

Reviewer 5:

The reviewer said that there seems to be good collaboration among the national laboratories.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer noted that the project has defined future pathways that are rational and logical. The reviewer remarked that the scalability of the manufacturing pathways chosen should be a primary emphasis to enable technology transfer.

Reviewer 2:

The reviewer commented that future research direction is well-provided by mentioning the development of novel gas atomization-based powder production methods sufficiently to replace the conventional energy and labor-intensive strip casting method. The reviewer noted that there are undoubtedly improvement opportunities in this fundamental research in the future.

Reviewer 3:

The reviewer observed that future research ideas are very good; however, the project team needs to specifically address the targets and challenges identified early in the presentation.

Reviewer 4:

The reviewer stated that proposed future research plans adequately identify the remaining technical issues that must be addressed. The reviewer offered that additional interaction with industrial stakeholders will maximize the chance that the technology will be commercially adopted.

Reviewer 5:

The reviewer said that the plan is reasonable if previous comments are addressed.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer mentioned that new materials are a critical enabler for next generation electrical machines.

Reviewer 2:

The reviewer stated that the project meets the DOE VTO objectives by eliminating heavy rare element use and achieving ultra-fine grain magnet technology. The reviewer suggested that the results are promising in terms of achieving the goals of this fundamental research. The reviewer remarked that the collaboration with other national laboratories and universities is noteworthy.

Reviewer 3:

The reviewer noted that this project fits very well with VTO objectives.

Reviewer 4:

The reviewer commented that the project is of prime relevance to the Electrification subprogram and addresses a critical need for the development of advanced and improved magnetic materials.

Reviewer 5:

The reviewer remarked that the targeted materials would improve motor performance, but this needs to be quantified.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer remarked that the project resources seem sufficient for the current scale of work pursued, but to enable future manufacturing scalability additional resources will be required.

Reviewer 2:

The reviewer noted that resources are adequate.

Reviewer 3:

The reviewer was sure that Covid impacted this project, just as it did most of the other projects. The reviewer expressed that it seems that there is a lot of work still needed to complete the project and measure the results against the goals and challenges. The reviewer suggested that perhaps a 1-year extension would be appropriate.

Reviewer 4:

The reviewer stated that further resources should be applied to this project to accelerate the development and commercialization of improved and advanced permanent magnets and soft magnetic materials. The reviewer suggested that the resources should be directed at the gaps preventing demonstration of pilot scale manufacturing of the technology.

Reviewer 5:

The reviewer declared that resources are sufficient based on the scope.

Presentation Number: ELT216
Presentation Title: Isotropic, Bottom-Up Soft Magnetic Composites for Rotating Machines
Principal Investigator: Todd Monson (Sandia National Laboratories)

Presenter

Todd Monson, Sandia National Laboratories

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 80% of reviewers felt that the resources were sufficient, 20% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

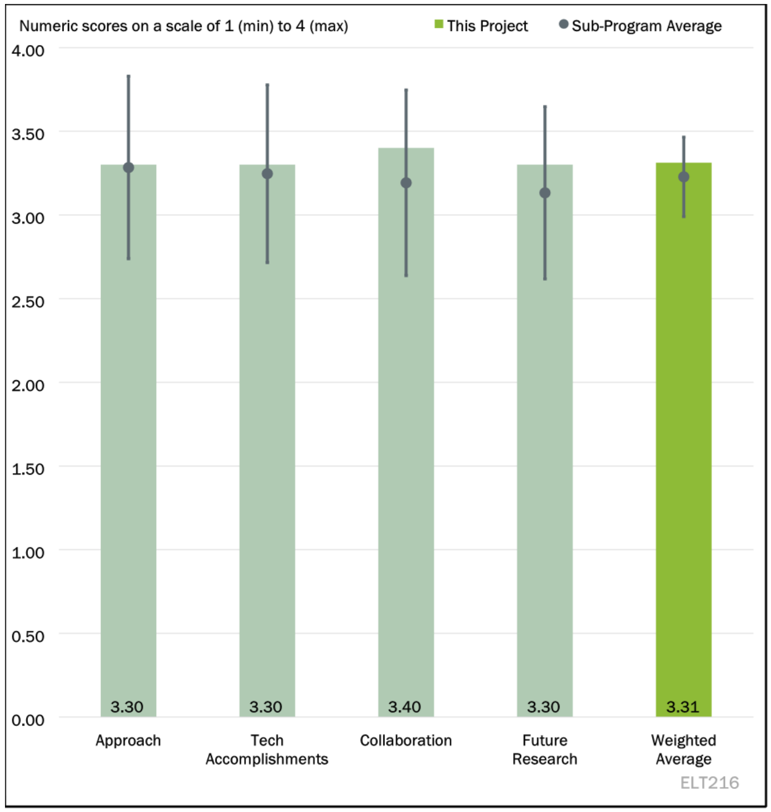

Figure 2-8 - Presentation Number: ELT216 Presentation Title: Isotropic, Bottom-Up Soft Magnetic Composites for Rotating Machines Principal Investigator: Todd Monson (Sandia National Laboratories)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer stated that the project has a clear aim of developing new soft magnetic materials for electric motor applications through a bottom-up manufacturing process involving high flux density iron nitride materials. The reviewer noted that a systematic approach to the work plan has been pursued with continued progress demonstrated.

Reviewer 2:

The reviewer remarked that the project aims to develop soft magnetic materials which have high performance magnetically. The reviewer said that if successful, alternative motors to permanent magnet motors can be achieved. The reviewer added that the project aims to eliminate cost barriers of rare earth elements and higher temperature capability. The reviewer observed that the work is consistent with replacing permanent magnets with soft magnet materials mentioned in the Electrical and Electronics Technical Team Roadmap as an alternative R&D pathway for achieving 2025 targets.

Reviewer 3:

The reviewer said that the approach and timeline are both appropriate for this project.

Reviewer 4:

The reviewer mentioned that the project addresses the technical barriers relevant to the engineering of a soft magnetic composite. The reviewer added that the project would be improved if the achieved and targeted properties were benchmarked against commercially available soft magnetic composites, like AncorLam and Somalloy.

Reviewer 5:

The reviewer suggested that a more detailed comparison of how the new material compare to commercially available materials should be provided.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer stated that the team has made substantial progress when benchmarked with prior reporting, including increases in magnetic volume fraction within composites, mechanical testing, and additional sample manufacturing to various geometries.

Reviewer 2:

The reviewer remarked that the project fabricated a 50% scale version of the dual rotor homopolar AC machine (DHAM) short stator assembly using 55% Fe_4N and developed protocols for fabricating, curing, and polishing Fe_4N/epoxy motor components. The reviewer added that tests were conducted to test the mechanical and electrical aspects of Fe_4N/epoxy composite properties. The reviewer commented that toroids for inductor design were built with the new material. The reviewer stated that it is good to see that the soft magnetic material developed is adapted to an actual machine design, and that this project demonstrates the material development concept to non-rare earth motor design.

Reviewer 3:

The reviewer noted that the technical progress is good; however, there is still a lot of work to get done with only 1 year remaining in the timeline.

Reviewer 4:

The reviewer observed that the project has systematically completed the significant structure, processing, and property milestones needed for a materials engineering effort.

Reviewer 5:

The reviewer mentioned that the detailed comparison of proposed motor with the novel material relative to a well-established baseline should be provided.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer noted that the team is effectively collaborating with numerous partners and is clearly identifying their contributions to the on-going work.

Reviewer 2:

The reviewer stated that the project collaborates with NREL, Ames National Laboratory, ORNL, Purdue University, and Illinois Institute of Technology (IIT). The reviewer observed that the engagement with Purdue University is focused on a motor design utilizing a DHAM that uses the proposed material. The reviewer said that this kind of engagement is appreciated to take the material science from the laboratory environment for an actual implementation on an end unit, in this case, a motor.

Reviewer 3:

The reviewer observed the excellent collaboration across the entire team and was sure that IIT will get more involved when dynamometer testing begins. The reviewer stated that the reference to ELT248 was also very good.

Reviewer 4:

The reviewer commented that the level of collaboration has been good and that it seems that the majority of the experimental work has been performed at NREL. The reviewer stated that the results of the DHAM motor prototype with the fabricated components will be critical to assessing the feasibility of the technology.

Reviewer 5:

The reviewer noted that there seems to be good collaboration among participating organizations.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer stated that the proposed future work is rational and will continue to yield progress towards the overall stated objectives. The reviewer declared that some questions remain which should be addressed to assist in further justifying the work plans and clarifying the overall project objectives:

Current saturation flux densities are approximately 1.2 T, how does this compare to state of art soft magnetic composites using more traditional metallic alloys? What advantages does the iron nitride approach yield at this flux density?

Permeabilities of more than 100 are targeted, how does such a low permeability impact motor performance in terms of efficiency and torque? What would be the ideal target if it could be selected?

Temperature stability is discussed for the epoxy but not the iron nitride material. Given that the stability of the nitride phase may be questioned by some potential end-users, it would be wise to clearly represent as compared to other thermal limitations associated with the composite materials.

Reviewer 2:

The reviewer observed that the proposed future includes fabricating the DHAM rotor and stator using soft magnetic components and continuing process and performance improvements of Fe_4N/epoxy composites. The reviewer added that epoxy is needed for high-speed operations of the motor, and there is a need to develop a sleeve. The reviewer said that it would be nice to see this work completed in the next budget period.

Reviewer 3:

The reviewer remarked that the future research has been clearly identified and is well aligned with the goals of the project.

Reviewer 4:

The reviewer noted that the future research plans include fabrication and testing of a DHAM prototype and further improvements in the material properties.

Reviewer 5:

The reviewer stated that previous comments need to be addressed.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer mentioned that the project is clearly aligned.

Reviewer 2:

The reviewer remarked that the project aims to develop soft magnetic material for motor design. The reviewer added that the proposed material can be used on motor topologies that do not have rare earth permanent magnets. The reviewer concluded that since rare earth materials are critical materials, this project aligns well with VTO subprogram objectives.

Reviewer 3:

The reviewer commented that this project fits very well into the objectives of VTO and that it seems that much more research in this particular area is justified.

Reviewer 4:

The reviewer affirmed that the project supports the Electrification subprogram objectives by demonstrating the performance of an advanced soft magnetic composite material.

Reviewer 5:

The reviewer noted that the project is relevant to the goal of eliminating rare-earth material but improvement in performance is not very clear.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that the current resources are adequate; however, if it is desired to explore manufacturing scalability, resource requirements will increase substantially.

Reviewer 2:

The reviewer remarked that the project has adequate resources to carry out the planned task.

Reviewer 3:

The reviewer noted that the project has huge potential but would need significantly more funding to achieve all of the potential milestones applicable to this technology.

Reviewer 4:

The reviewer said that the resources are sufficient.

Reviewer 5:

The reviewer observed that the resources sufficient based on scope.

Presentation Number: ELT219
Presentation Title: Power Electronics Materials and Bonded Interfaces-Reliability and Lifetime
Principal Investigator: Paul Paret (National Renewable Energy Laboratory)

Presenter

Paul Paret, National Renewable Energy Laboratory

Reviewer Sample Size

A total of six reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 83% of reviewers felt that the resources were sufficient, 17% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

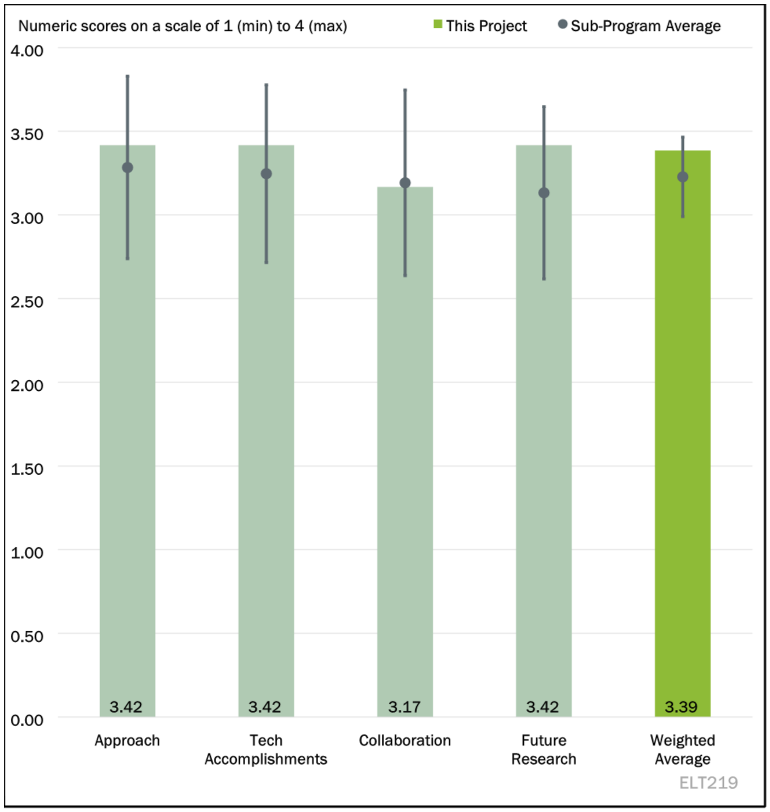

Figure 2-9 - Presentation Number: ELT219 Presentation Title: Power Electronics Materials and Bonded Interfaces-Reliability and Lifetime Principal Investigator: Paul Paret (National Renewable Energy Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer stated that the team is using an appropriate mix of destructive and non-destructive testing and is comparing the test results to prediction models.

Reviewer 2:

The reviewer noted that the reliability of bonded interfaces in power modules is critical to the reliability of power electronics converters. The reviewer added that the team has designed an excellent approach to study the issue through a combination of sample preparation, testing, and finite-element analysis.

Reviewer 3:

The reviewer remarked that the scope of work involves systematic variation in processing of bonded interfaces, a critical component of device reliability. The reviewer added that variations are followed by imaging and thermal and mechanical testing to confirm adhesion and quality of bonds. The reviewer suggested that additional consideration should be made for using electrical and thermal performance metrics to assess bond quality and performance in addition to mechanical adhesion.

Reviewer 4:

The reviewer noted that the project looks to evaluate polymeric and copper bonding approaches in addition to machine learning techniques for life prediction to understand capabilities of the technologies. The reviewer mentioned that the approach seems good but that the grid and stripe patterning for the Cu bond layer is a little strange and might actually induce failure earlier than expected due to more stress concentrations at the edges of the grids or stripes and localization of heat during actual power device operation. The reviewer recommended to study these possible effects if the researchers decide to proceed with the approach.

Reviewer 5:

The reviewer noted that the reliability evaluation of bonded interfaces and the lifetime prediction model based on time-series forecasting are critical elements. The reviewer expressed that the missing element is that of the joint fabrication process. The reviewer explained that the manufacturing process is just as big a factor as the material makeup of the joint. The reviewer added that without control or at least full understanding of what is being fabricated, it is difficult to know what the experimental research results mean.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer stated that the team has fabricated and tested multiple bonding materials and methods. The reviewer added that the sintered copper results are a little bit difficult to interpret. The reviewer remarked that the team has compared time-series forecasting to machine learning and demonstrated the superiority of statistical models, and that this is encouraging and illustrates the importance of evaluating a range of approaches. The reviewer commented that on Slide 8, there is a graph that is totally unreadable for someone who is colorblind because the color contrast is not sufficient. The reviewer explained that this is a situation where marker types or line styles would be extremely beneficial so as not to rely on color alone to communicate; by comparison, Slides 7, 11, and 12 are excellent from that perspective.

Reviewer 2:

The reviewer observed that the team has made significant progress in evaluating the reliability of polymer-bonded interfaces by sample synthesis and testing. It was not clear to the reviewer why the two polymers were selected for study. The reviewer found that reliability evaluation of sintered-copper interface was interesting and looks forward to seeing more results in the following year.

Reviewer 3:

The reviewer said that the project seems to be tracking according to the initial plan.

Reviewer 4:

The reviewer noted that good progress is made across all thrusts.

Reviewer 5:

The reviewer stated that given the level of funding, progress was reasonable.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer stated that while the team overall seems appropriate, the relative contributions of Georgia Tech and the three national laboratories is unclear.

Reviewer 2:

The reviewer noted the excellent collaboration with Institute of Innovative Mobility (IIMo) leading to the sintered copper samples.

Reviewer 3:

The reviewer remarked that the sample exchanges between project partners have been effective, but that it is not clear if there is strong interaction with other national laboratory partners given the work scope.

Reviewer 4:

The reviewer commented that it was not very clear beyond the simple one-line sentences in the presentation what the contributions of the various partners is.

Reviewer 5:

The reviewer did not see much detail of the level of collaboration and stated that there is a need to better understand exactly what is being done by each of the participants.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer stated that the team has identified the issues with their work up to this point and identified the appropriate next steps to explore reliability of all three bonding technologies.

Reviewer 2:

The reviewer noted that the proposed future activities are excellent and in line with the program objectives and approach.

Reviewer 3:

The reviewer commented that, as noted above, the project should work towards electrical and thermal performance figures of merit as the project matures. The reviewer added that given the early status, it is expected that the project will be focused on earlier screening and assessment methods.

Reviewer 4:

The reviewer suggested that it would be nice to see the development of constitutive models for enhanced numerical study of these newer materials being proposed, but it was not.

Reviewer 5:

The reviewer noted that based on the budget, the proposed future research is reasonable.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer stated that bond reliability is essential in all power electronics packages.

Reviewer 2:

The reviewer said that understanding the reliability of bonded interfaces, which determines the reliability of power modules and power converters is critical for achieving the VTO Electrification's targets for electric traction drives.

Reviewer 3:

The reviewer commented that bond reliability can be a critical factor in dictating the overall lifetime, and that the project is highly relevant to overall goals.

Reviewer 4:

The reviewer noted that the project furthers the advancement of electrified vehicle systems with WBG devices.

Reviewer 5:

The reviewer noted that this area will be a key factor in increased power density and lower cost.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer declared that the work appears to be properly scaled to the resources available.

Reviewer 2:

The reviewer noted that the project has adequate resources.

Reviewer 3:

The reviewer observed that for the current scope of work, the resources seem reasonably aligned. The reviewer suggested that future years should reassess based on progress and proposed future work efforts.

Reviewer 4:

The reviewer stated that resources seem sufficient, but they could be enhanced if the researchers can better develop constitutive models.

Reviewer 5:

The reviewer said that this project should be more comprehensive. The reviewer remarked that there should be a team working on the manufacturing processes with the materials selection, then a team doing the evaluation. The reviewer noted that right now there is just a team working on the evaluation of the fabricated joints.

Presentation Number: ELT221
Presentation Title: Integrated Electric Drive System
Principal Investigator: Shajjad Chowdhury (Oak Ridge National Laboratory)

Presenter

Shajjad Chowdhury, Oak Ridge National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 25% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

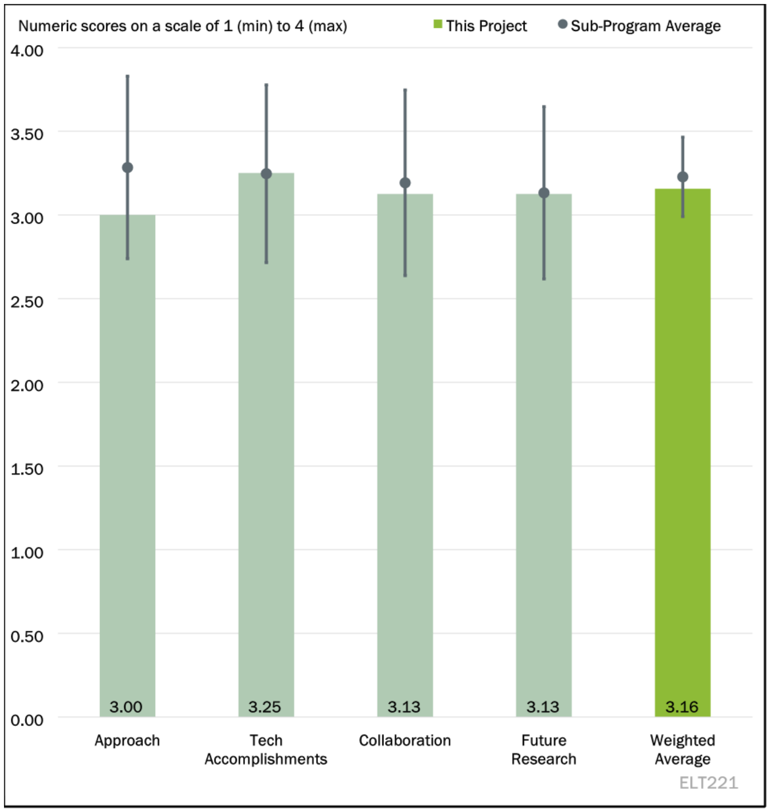

Figure 2-10 - Presentation Number: ELT221 Presentation Title: Integrated Electric Drive System Principal Investigator: Shajjad Chowdhury (Oak Ridge National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer stated that the technical barriers are mentioned and addressed appropriately.

Reviewer 2:

The reviewer asked if the primary goal is to build a high-power density inverter and integrate it with the electric machine without any efficiency targets to be met, or if the efficiency targets will be specified in the design of the individual components. The reviewer explained that without a minimum efficiency target, it may be possible to build an integrated high-power density electric drive machine (EDM) using a cooling strategy which would otherwise be unacceptable. The reviewer added that if it is not the case, it would still be good to clarify the efficiency targets. The reviewer noted that there appears to be no stated cost target either. The reviewer did not have a good idea of the costs involved, but asked if moving to a modified DBC substrate or DBC with TPG would adversely impact the cost.

Reviewer 3:

The reviewer remarked that all the relevant thermal and electromagnetic barriers seem to be adequately addressed, and that mechanical stresses due to coefficient of thermal expansion will be addressed in the future.

Reviewer 4:

The reviewer observed that most of the details are focused on the inverter design, and that there were not enough details about the integration of the inverter and the motor as well as the overall thermal management system.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer commented that the project appears to be on track and all the promised deliverables met.

Reviewer 2:

The reviewer remarked that the completed testing is in line with the milestones and go/no-go decision gates. The reviewer added that the test results also support the going in postulates and provide the cooling performance improvement that is needed to achieve the high-power density.

Reviewer 3:

The reviewer stated that the team has made good progress towards meeting the technical project goals.

Reviewer 4:

The reviewer observed that there was good progress on designing the inverter. The reviewer added that the choice of an outer rotor motor design might not be optimum and actually limiting, as outer rotor motors are known to have several mechanical challenges. The reviewer stated that more specific details about the system integration should be provided, and that more thermal and mechanical analysis of the overall system should be provided.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer declared that clear leadership is evident, which drives results. The reviewer encouraged more industry involvement so as to insure relevancy. Overall, the reviewer was glad to see the ability to leverage strengths of the individual national laboratories.

Reviewer 2:

The reviewer noted very good collaboration with the other national laboratories; however, it may be beneficial to have commercial manufacturers on power inverters involved to better assess impact of chosen design on piece cost in volume production, or any other issues such as reliability, durability, and variability that may arise.

Reviewer 3:

The reviewer commented that the results from collaboration with NREL, Sandia, and Ames have not been presented yet.

Reviewer 4:

The reviewer remarked that there seems to be collaboration among several organizations, but more specific details need to be provided.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer stated that the project is on track, clearly defined and documented, and the reviewer is looking forward to next year.

Reviewer 2:

The reviewer said that the future plan looks good, but as mentioned in an earlier section, it would be good to have some clear system level efficiency and cost targets specified for this project.

Reviewer 3:

The reviewer noted that the proposed research adequately addressed the main challenges and is likely to achieve its targets.

Reviewer 4:

The reviewer observed that, in general, the direction is good but some of the areas that need more details should be addressed.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer stated that this project is one of electrification’s top current projects.

Reviewer 2:

It was not clear to the reviewer how feasible it will be to use the EDM configuration that is being developed in this project in serial production, but nevertheless, the reviewer expressed that the experience gained and techniques developed here could be deployed in other configurations in the march towards developing a high-power density and cost effective electric drive unit.

Reviewer 3:

The reviewer noted that the project is directly relevant towards meeting the Electrification subprogram’s 2025 power density target of 33 kW/L.

Reviewer 4:

The reviewer commented that the end goal of having tightly integrated systems with improved thermal performance is relevant.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that the cost appears to be insufficient and suggested increasing it.

Reviewer 2:

The reviewer thought the resources are sufficient.

Reviewer 3:

The reviewer declared that the project appears to have sufficient resources to achieve the stated milestones.

Reviewer 4:

The reviewer believed that the resources are sufficient based on the proposed scope.

Presentation Number: ELT223
Presentation Title: Component Testing, Co-Optimization, and Trade-Space Evaluation
Principal Investigator: Jason Neely (Sandia National Laboratories)

Presenter

Jason Neely, Sandia National Laboratories

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 67% of reviewers felt that the resources were sufficient, 33% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

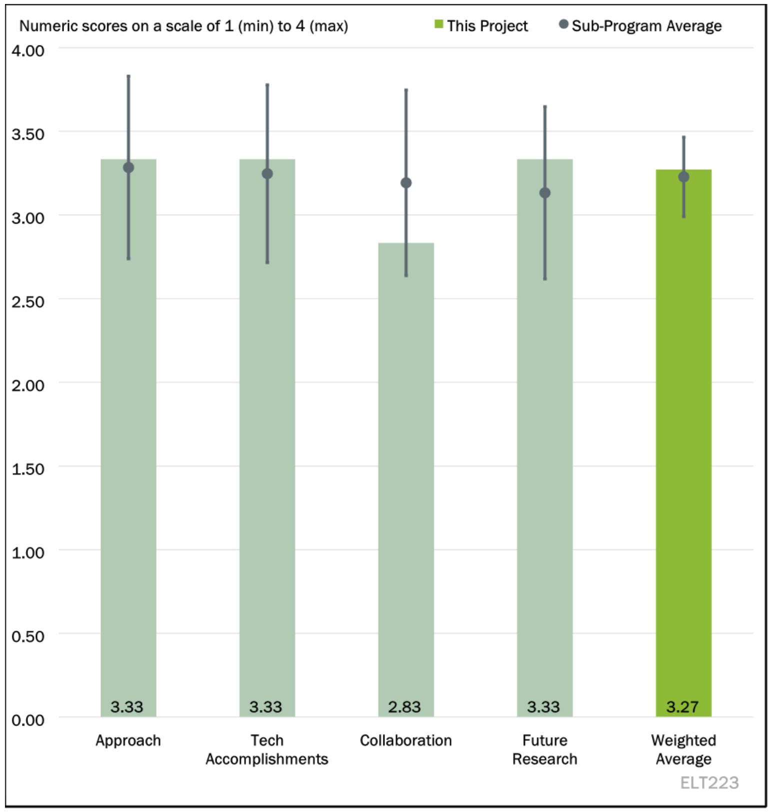

Figure 2-11 - Presentation Number: ELT223 Presentation Title: Component Testing, Co-Optimization, and Trade-Space Evaluation Principal Investigator: Jason Neely (Sandia National Laboratories)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer noted the excellent use of the modeling tools, and that sufficient detail was included to clearly understand the approach.

Reviewer 2:

The reviewer commented that in general, vehicles sold in the United States are going to require higher power than 100 kW, because SUVs and trucks make up a large percentage of vehicles sold. The reviewer added that 100 kW peak power rating will correspond to perhaps about 50 kW continuous power. The reviewer stated that if a vehicle is loaded up to its gross vehicle weight rating, or it is towing a payload, and driving on a freeway at more than 70 mph for extended periods of time, the continuous power rating becomes critical. The reviewer concluded that a 100 kW peak power machine would be woefully inadequate and using the Supplemental Federal Test Procedure (SFTP or EPA US06) as a mission profile to evaluate operational life may not be sufficient. The reviewer did not know about Tesla, but legacy OEMs generally design their vehicles to meet the needs of a 95% customer. The reviewer said that this generally means requiring the vehicle to be able to pass more extreme test conditions, such as driving up the Davis Dam grade at 65 mph, while towing, at ambient temperatures of 1100°F. The reviewer suggested seeing SAE J-2807 for towing requirements. The reviewer mentioned that certification cycles, like Federal Test Procedure (FTP) 5 cycle, are required to be used by OEMs to calculate vehicle range; however, it is also worthwhile to include efficiency calculations using more “real world” type of driving. The reviewer noted that a lot of work in this area has been done at NREL and has been presented in past AMRs. The reviewer mentioned that verifying the efficiency gains using real world driving cycles ensures that the efficiency gains seen in the calculations are actually seen by the consumer, and the former goal of petroleum displacement is actually achieved.

Reviewer 3:

The reviewer stated that issues that go along with implementing surround cooling, or distributed bus filtering have not been identified, and that the evaluation needs to measure these other potential issues for the technology to be usable.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer noted that the technical progress has been in line with the original objectives and that the approach is very disciplined. The reviewer remarked that it was very interesting that increasing the flow rate to 600 mm^3/sec had little impact to the results on Slide 5.

Reviewer 2:

It appeared to the reviewer that the project has taken direction which have not led to fruitful results by utilizing a distributed bus filter, but it is still valuable information that is gained by trying these approaches and should benefit future projects. The reviewer explained that one issue with the distributed filter approach is the reliance on higher switching frequency (100 kHz), which appears to require GaN components. The reviewer added that most manufacturers are not considering GaN semiconductors as an option yet because of limited reliability and that this would be in direct contrast to the stated goal of 300,000 miles.

Reviewer 3:

The reviewer stated that based on the budget, the progress is reasonable, but the reviewer saw gaps in this project. The reviewer explained that there needs to be a more holistic approach that encompasses all issues around the technologies being pursued.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer stated that it was not clear from the presentation which parts of this project were performed by each of the team members and suggested that more detail should be included in the final report.

Reviewer 2:

The reviewer commented that while collaboration with other national laboratories and universities has been excellent, the project could definitely benefit from some involvement from the industry as well. The reviewer noted that any of the points made in the above response are from an industry perspective.

Reviewer 3:

It was not clear to the reviewer to what extent the activity between collaboration participants exists other than the statements on Slide 16.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer said that the proposed future work is in line with the original project objectives.

Reviewer 2:

The reviewer remarked that the proposed future work is very worthwhile. Regarding the multi-objective optimization approach, and after over thirty years in the industry, the reviewer held the very contrary opinion that in many cases multi-objective optimization does not necessarily yield a solution that is implementable. The reviewer explained that it is a great approach when developing a one-off prototype which has very specific requirements. The reviewer added that in practice though, the same components of power electronics, electric machines, etc. will have to be used in multiple vehicle programs in order to keep the cost within reason. The reviewer concluded that the requirements on the components span a wide range in terms of power, torque, packaging, mission profiles, etc., but they all have to be met by the same set of components. The reviewer said that this, in most cases implies that, components that end up being used are not usually those that are arrived at as the outcome of a multi-objective optimization.

Reviewer 3:

The reviewer stated that the proposed work for Fiscal Year 2024 seems to be reasonable given the current project status.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer remarked that the relevance and objectives identified are aligned with VTO objectives.

Reviewer 2:

The reviewer said that the project is definitely relevant, and that any progress made that will help improve vehicle range, cost, performance, and would lead to adoption of these ideas by the industry would be beneficial.

Reviewer 3:

The reviewer stated that this is an important area of work, but believed it needs to be more in depth in order for it to be really valuable to industry.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

It appeared to the reviewer that the resources have been distributed over the 5-year timeframe effectively.

Reviewer 2:

The reviewer said they are sufficient.

Reviewer 3:

The reviewer stated that there needs to be a more in-depth project defined to answer the questions the current project is trying to answer, and that this will take more resources to be done properly.

Presentation Number: ELT236
Presentation Title: Direct-Current Conversion Equipment Connected to the Medium-Voltage Grid for Extreme Fast Charging Utilizing Modular and Interoperable Architecture
Principal Investigator: Watson Collins (Electric Power Research Institute)

Presenter

Watson Collins, Electric Power Research Institute

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

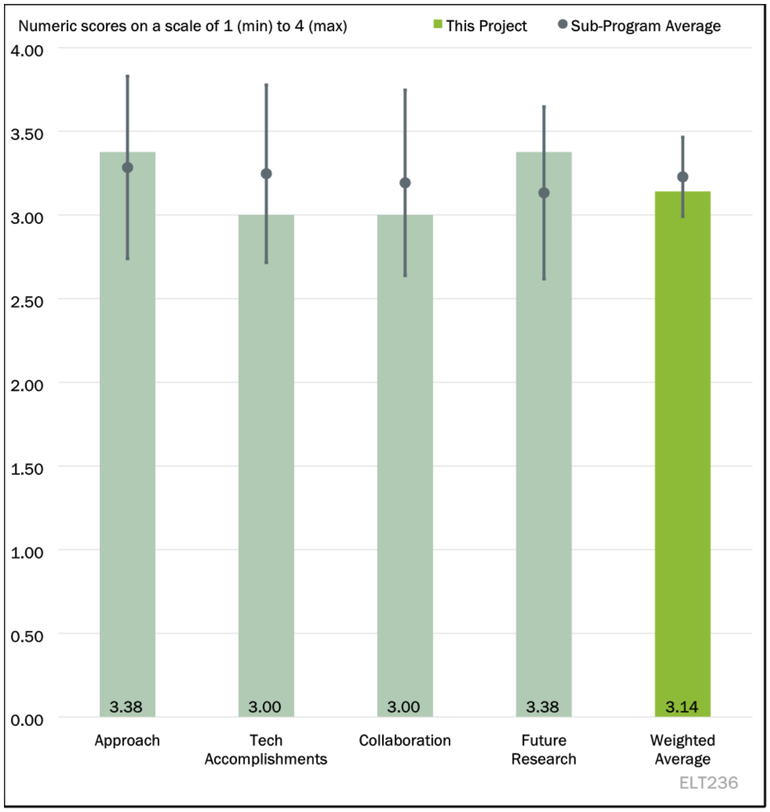

Figure 2-12 - Presentation Number: ELT236 Presentation Title: Direct-Current Conversion Equipment Connected to the Medium-Voltage Grid for Extreme Fast Charging Utilizing Modular and Interoperable Architecture Principal Investigator: Watson Collins (Electric Power Research Institute)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer stated that the project appropriately segments the work into five core components: utility interface; medium voltage converter (solid-state transformer); DC load center; direct current fast chargers (DCFCs); and testing with extreme fast charging capable vehicles. The reviewer added that all segments are pushing the envelope of technology as commercial components for each are still in development or just coming to the market.

Reviewer 2:

The reviewer mentioned that the technical barriers are being addressed and the project design is appropriate. The reviewer added that one possible shortcoming is that there is no mention of evaluating the reliability of the solid-state transformer.

Reviewer 3:

The reviewer noted that the project is on track.

Reviewer 4:

The reviewer commented that one technical barrier that this project seeks to address is integrating distributed energy resources (storage, solar, wind, etc.) to enable management of DC connected EV charging. The reviewer added that as the project proceeds, the degree to which the equipment solves this integration can be explored further.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer remarked that there was good progress on solid-state transformer with the design completed and prototype cells tested, request for quotes issued, and four vendors short-listed, and on the DC load center which was built and tested. The reviewer added that due to supply chain delays, the three 360 kW Tritium DC charging heads are delayed until 2024, but instead a 150 kW prototype has been delivered to NREL for testing with laboratory equipment.

Reviewer 2:

The reviewer commented that the progress is good considering that much of the original project schedule has been delayed by Covid and supply chain issues.

Reviewer 3:

The reviewer affirmed that there is a need to assure all test conditions are considered especially environmental and temperature variations.

Reviewer 4:

The reviewer stated that, as reported, the project did face challenges with the supply chain interruptions and changes in vendor participation. The reviewer noted that the project team awaits delivery of hardware components before they can be assembled in one location and tested at the NREL facility.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer commented that Electric Power Research Institute (EPRI) as the project lead is collaborating with Tritium as a DC charging heads supplier and NREL for comprehensive system testing. The reviewer added that Argonne National Laboratory was listed as a project partner, but their role was not mentioned in the presentation.

Reviewer 2:

The reviewer stated that the partner participation appears to be balanced and appropriate.

Reviewer 3:

The reviewer noted that this section was not adequately presented.

Reviewer 4:

The reviewer commented that, notwithstanding supply chain and vendor response or delays, the project team noted it is expecting to take delivery on hardware components, which can then be assembled and tested by NREL. The reviewer added that the team noted an increasing number of manufacturers and vendors are building prototypes of solid-state transformers, for example, so the options may be growing in the market. The reviewer concluded that the team seems to be bringing together the collaborators well.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer stated that due to the supply chain delays the three Tritium 360 kW DC charging heads are anticipated to arrive at NREL in 2024 for system testing. The reviewer added that the demonstration site selection is to be made by the end of budget period three, and that the team is currently considering a utility site in Pomona, California, which will be ready in 2023.

Reviewer 2:

The reviewer mentioned that future research appears outstanding because it addresses quantifying the reliability and resiliency of the DC infrastructure and proposes to perform additional integration of the DC microgrid with medium voltage converters. The reviewer added that the proposed failure mode analysis would also be useful for assessing this project’s architecture.

Reviewer 3:

The reviewer suggested that the project team needs more test data and test conditions especially regarding impact and interface to grid.

Reviewer 4:

The reviewer remarked that the goal of enabling charging hardware that is interoperable and easily buildable and scalable (modular) supports the goals of VTO. The reviewer added that future work should show the interoperability, modularity, and scalability of the architecture. The reviewer commented that the project team proposes additional integration testing, megawatt charging implementation, dynamic response to unexpected system conditions, failure mode analysis, reliability and resiliency monitoring, and other future potential work. The reviewer suggested that it is important in considering future work, to seek input from eventual day-to-day users like the companies or fleets who own facilities where charging might occur or who run EVs and would utilize the integrated charging in their operations.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer mentioned that establishing a foundational system for DC connected EV charging that integrates with devices such as distributed energy resources, solar, wind, and energy storage contributes to addressing the VTO Electrification subprogram objectives to support electric transportation. The reviewer added that developing and testing extreme fast charging technologies while minimizing impacts to the grid directly supports the Grid and Charging Infrastructure program goals.

Reviewer 2:

The reviewer stated that this project is relevant to VTO Electrification subprogram objectives to develop enabling technologies for transportation electrification to include charging architectures that integrate with the electrical grid and distributed energy resources. The reviewer added that this project develops technologies that minimize the number of power conversion steps and uses a solid-state transformer and novel central DC load center.

Reviewer 3:

The reviewer offered that the project team needs to quantify economic values and impact.

Reviewer 4:

The reviewer remarked that this project is relevant to VTO subprogram objectives, particularly Electrification and grid integration activities. The reviewer added that the Batteries subprogram seeks to enable extreme fast charging for EV batteries, and this project also helps enable extreme fast charge (XFC) goals.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that $5 million total funding with $2.6 million DOE share seems appropriate for a grid integrated megawatt charging technology development project that is spanning nearly 7 years with the sought extension.

Reviewer 2:

The reviewer noted that the resources appear to be sufficient if the timeline is extended to allow the supply chain issues to be resolved; however, it is unclear whether the solid-state transformer (SST) manufacturing quotes will present a resource constraint issue.

Reviewer 3:

The reviewer remarked that the project is on track.

Reviewer 4:

The reviewer declared that the project team appears to be near completion of its work, though with an extension sought, but it was unclear whether it is a no-cost extension or if they are seeking additional funding.

Presentation Number: ELT238
Presentation Title: Intelligent, Grid-Friendly, Modular Extreme Fast Charging System with Solid-State Direct-Current Protection
Principal Investigator: Srdjan Lukic (North Carolina State University)

Presenter

Srdjan Lukic, North Carolina State Unviersity

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

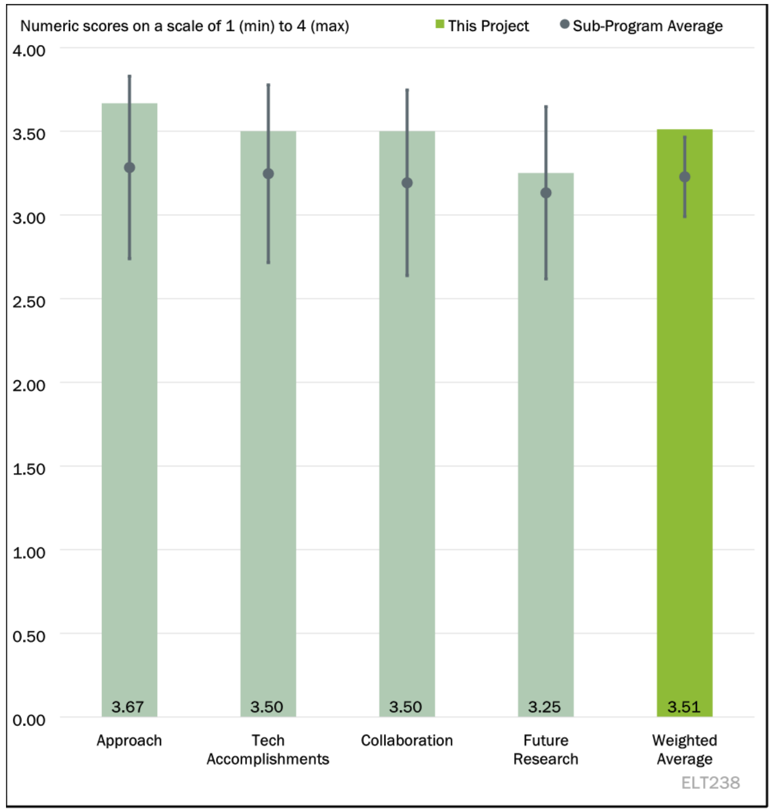

Figure 2-13 - Presentation Number: ELT238 Presentation Title: Intelligent, Grid-Friendly, Modular Extreme Fast Charging System with Solid-State Direct-Current Protection Principal Investigator: Srdjan Lukic (North Carolina State University)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer commented that great progress has been made on this project and with only field demonstration and testing remaining, it appears that the technical issues have been adequately addressed thus far. The reviewer added that the proof will now be in the installation and test.

Reviewer 2:

The reviewer remarked that this project has developed a prototype of extreme fast charging system rated at 1 megavolt-ampere (MVA). The reviewer added that since this is quite an expensive system, its uptime is crucial from a payback time standpoint. The reviewer stated that to ensure high uptime, the project team has developed a protection system capable of isolating the faulty portion of the power circuit within the extreme fast charging (XFC) system, followed by its testing with a single fault injected at a time. The reviewer concluded that overall, the approach was towards the realization of a reliable extreme fast charge (XFC) system.

Reviewer 3:

The reviewer noted that the approach follows three logical phases, and that the speaker's description provided details of each phase and the logical steps in each phase.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer stated that the plan was executed as architected with the only notable exception being the system assembly. The reviewer added that it has delayed the rest of the program, causing the system testing to be outside the originally proposed project plan, but that it will get covered in a no-cost extension. The reviewer noted that the delay is understandable as global supply chain issues impacted many industries. The reviewer said that significant work was performed on the solid-state transformers and solid-state breakers that can be a benefit to projects outside of this one. The reviewer remarked that these should be thoroughly tested both inside and outside the overall system. The reviewer realized that the installation and field test has yet to begin but suggested that the team be certain to have a thorough and comprehensive test plan to fully test single and double faults through combinations and permutations. The reviewer stated that even now, before installation, the fault detection and control logic can be tested on a low-voltage bench; there was no mention of it. The reviewer said that one of the key aspects of this project is to bring fault tolerance and fault isolation, and that it needs to get thoroughly tested before the conclusion of this project.

Reviewer 2:

The reviewer commented that the first budget period of the project was dedicated to system development including identification of a test site, and that the second budget period was utilized for system integration including test site preparation and validation of a protection system for the XFC prototype. The reviewer added that budget period three activities are targeted for system deployment of 1 MVA XFC. The reviewer explained that dual active bridge (DAB)-based SST architecture was defined for direct interface of XFC with 13.2 kV line-to-line electric grid, and that the SST module design was completed including its thermal management system. The reviewer noted that SST efficiency was evaluated including the efficiency of various components over power range from 5 kW to 55 kW. The reviewer said that SST is under test in the North Carolina State University (NCSU) laboratory, and the distributed DC charging concept was illustrated in ELT238 project's AMR report. The reviewer added that the performance of a solid-state circuit breaker (SSCB) was evaluated, and sample test results were included in the ELT238 project's AMR report. The reviewer noted that the system level protection tests passed with one fault at a time and the faulty portion was successfully separated from rest of the XFC system. The reviewer remarked that the XFC system domestications were planned, however subject to approval from NYPA, and that the test site layout is included in the ELT238 project's AMR report.

Reviewer 3:

The reviewer observed that much of the presentation is the same as the 2022 presentation, including budget, accomplishments, plan to complete, and plan to submit a no-cost time extension. The reviewer added that the speaker's presentation was very informative and described the development, testing, integration, and refinement process that has been applied to all project aspects. The reviewer stated that the project innovations and results are very impressive including the smaller system footprint, volume, and mass, with higher power, higher efficiency at lower system-level cost. The reviewer commented that the SSCB fault current performance of 10–100 micro-seconds is impressive, and that all reported component and system testing was passed. The reviewer mentioned that a demonstration system is developed into a shipping container enclosure and being installed at a NYPA site for testing.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer stated that there is an acceptable group of collaborators that have been working well with each contributing their respective strengths and designed roles. The reviewer thought that the selection of ABB and New York Power Authority (NYPA) are great partners for this project. The reviewer suggested that the team could be enhanced with the addition of one of the strong power electronics national laboratories, but the project is executing to plan without it.

Reviewer 2:

The reviewer remarked that a strong collaboration exists in execution of project activities and multiple entities are involved in the NCSU-led project.

Reviewer 3:

The reviewer commented that NCSU Freedom Center's lead for project innovations and leadership appears to be strong. The reviewer added that ABB's leading high-power electrical, power electronics, and charging station development and manufacturing has been a great inclusion in the project. The reviewer said that NYPA is an ideal test and evaluation partner, and as a self-permitting entity, is streamlining the demonstration phase installation and testing.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer did not see any future research suggested for this project, aside from wrapping up the install and testing of the existing project.

Reviewer 2:

The reviewer remarked that there was no data included in report. The reviewer added that this is the last budget period, with only one major task incomplete, which is the verification of 1 MVA XFC at test site in New York.

Reviewer 3:

The reviewer observed that future work will install the prototype system at the NYPA facility and demonstrate and evaluate the performance.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer commented that the project presents a usable framework for potential lower operating cost and installation cost for extreme fast charging networks from a medium voltage distribution. The reviewer added that this can help to accelerate charging infrastructure.

Reviewer 2:

The reviewer stated that this project is relevant to VTO sub-program in the electrification area and will accelerate adoption of EVs by increasing the availability of XFC to HD and light-duty vehicles and utilities will feel comfortable in allowing XFC interface with medium voltage (MV) grid.

Reviewer 3:

The reviewer noted that the project is developing an innovative approach to significantly reduce the size, cost, installation cost, and operational flexibility of banks of high-power DCFC equipment. The reviewer added that this is a critical need given the country's and world's rapid and concurrent transition to electrified transport.

The reviewer stated that having electric vehicle supply equipment (EVSE) manufacturer ABB involved with a strong project role increases the relevance rating since it is more likely to be used or leveraged for commercial applications.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer did not think that there have been or will be issues on project resources, unless they have far underestimated the planned installation.

Reviewer 2:

The reviewer stated that the project has necessary resources and research funds.

Reviewer 3:

The reviewer mentioned that bringing unique expertise together for a project like this is not trivial. The reviewer explained that the high-level funding description in the presentation seems like a good balance of funding and cost share to accomplish the project with a reasonable budget.

Presentation Number: ELT239
Presentation Title: High-Power Inductive Charging System Development and Integration for Mobility
Principal Investigator: Omer Onar (Oak Ridge National Laboratory)

Presenter

Omer Onar, Oak Ridge National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

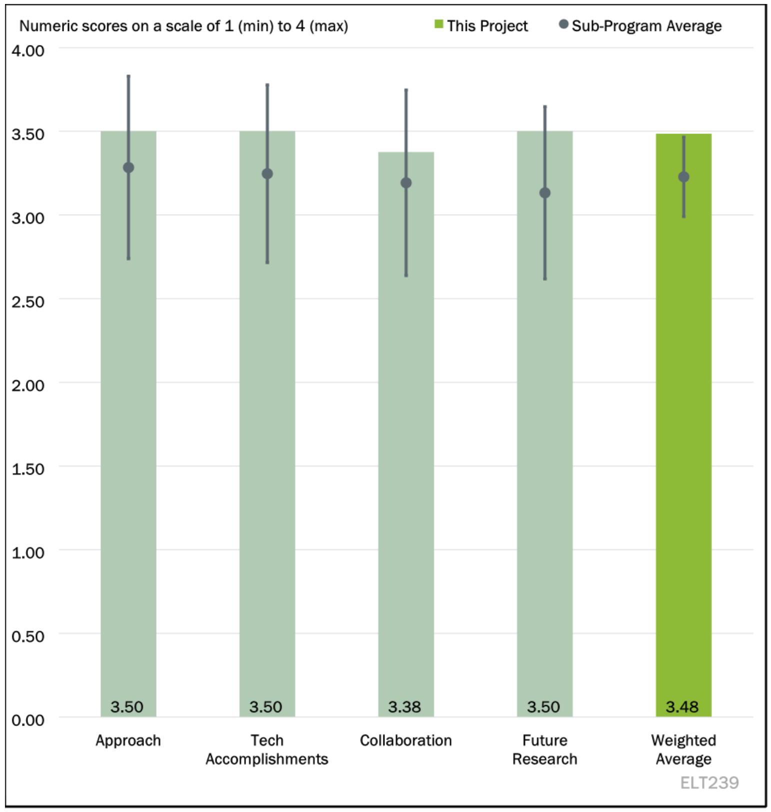

Figure 2-14 - Presentation Number: ELT239 Presentation Title: High-Power Inductive Charging System Development and Integration for Mobility Principal Investigator: Omer Onar (Oak Ridge National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer said that the project team sought to develop a high-powered inductive charging system and has done so for 100 kW—20 minutes to full charge—and is currently working on integrating the 270 kW version for the Porsche. The reviewer added that the project design is thorough and has proven a successful path to the development of this charging system. The reviewer noted that the timeline planned is reasonable; however, more time refining and testing will need to be done beyond the dates of this project to reach the marketable stage.

Reviewer 2:

The reviewer remarked that the approach covers system design, modeling, and simulation of the grid interface, and testing in the laboratory and in vehicle validation.

Reviewer 3:

The reviewer observed that the project is nearly complete. The reviewer added that the presentation detailed the project approach from modeling to component development and validation, to subsystem and system development and validation, and finally full-scale demonstration bench then vehicle. The reviewer stated that the schedule to achieve this was realistic and the project remained on track, at least at the budget period-level as reported). The reviewer noted that the more than 94% efficiency exceeds the 90% target. The reviewer commented that the barriers and objectives mentioned "Maintaining high power quality on the grid side (less than or equal to 5% on current harmonics, greater than or equal to 95% input power factor)," but that neither was mentioned in the presentation.

Reviewer 4:

The reviewer stated that the approach is well known and established in previous and similar research projects.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer said that with just months left in this project, the team has completed nearly all milestones, and are working on the 270 kW integration, testing, and demonstration. The reviewer added that the team met its greater than 90% operating efficiency goal thus far. The reviewer noted that, as indicated in the presentation, refining of the prototype continues and it is anticipated that development of this charging system will not end at the project end date. The reviewer stated that in all probability, there will be more work done here outside of this 5-year project. The reviewer commented that with these successes, there will be more testing and validation, particularly in real-world conditions, and the designing of enclosures, before this product is marketable.

Reviewer 2:

The reviewer observed that significant technical accomplishments include: completing inverter design with 55 kW/L power density; designing vehicle-side rectifier; completing ground and vehicle coupler designs and developments; finalizing coupler specifications; and performing experimental testing of the 100 kW system with overall efficiency exceeding 94%.

Reviewer 3:

The reviewer mentioned that the project remained on schedule and achieved very good power transfer performance with higher efficiency than targeted. The reviewer said that different coil winding approaches were investigated to maximize performance and tradeoffs. The reviewer observed that barriers and objectives of "Maintaining high power quality on the grid side (less than or equal to 5% on current harmonics, greater or equal to 95% input power factor)" were not discussed in the presentation. The reviewer added that thermal management was mentioned as a challenge in the 2022 and 2023 presentations. The reviewer stated that the final steps of the 270 kW system integration and demonstration and addressing thermal and electromagnetic interference (EMI) issues will be completed by the project close.

Reviewer 4:

The reviewer stated that the project team still needs to evaluate and test in real world conditions.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer stated that the presentation clearly indicates the roles of each of the team—national laboratory and two EV OEMs. The reviewer had no doubt that each partner brought 110% to the project as the development of an inductive charging system is a game changer for all parties involved. The reviewer concluded that as a team, they have the skills to make it happen.

Reviewer 2:

The reviewer commented that ORNL's project partners include two large automotive manufacturers in Hyundai-Kia America Technical Center and Volkswagen Group of America's Innovation Hub.

Reviewer 3:

The reviewer remarked that the coordination between ORNL and the OEM partners, Hyundai and Volkswagen, and the roles of each, with ORNL as the clear lead, were well described and logical. The reviewer added that Hyundai supported the vehicle and battery management system integration (100 kW system). The reviewer noted that Volkswagen did the same for the Porsche demonstrator (270 kW system), but the collaboration is more in-depth to understand how to move this in the future to a commercial product for manufacturing, cost, packaging, etc. that is important for commercialization. The reviewer stated that the presenter also noted several related wireless charging projects that involved other vehicle OEMs, as well as mentioned discussions are being held with other OEMs. The reviewer observed that the actual commercial interest in the topic and project is key to justify the current and potential future funding for wireless charging research.

Reviewer 4:

The reviewer stated that collaborations seem to be fine, with nothing being extraordinary.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer remarked that the presentation indicates as future work: "Perform vehicle integrations for demonstrations for 270 kW power level on Porsche Taycan research vehicle." The reviewer noted that there is no doubt that future work will occur, and this product's development will move forward.

Reviewer 2:

The reviewer commented that future research is appropriate as it includes completion of a 3-year budget period by Sept. 2023 to complete system integration and installation into a vehicle to validate 270 kW power transfer.

Reviewer 3:

The reviewer stated that the proposed future research clearly addresses the few remaining items of the scope, including thermal management, EMI, and integrating and testing the 270 kW system on the Porsche Taycan.

Reviewer 4:

The reviewer recommended having a detailed design validation plan and report (DVP&R) driven by requirements and real-world test conditions.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer stated that the development of this product affects all subprograms listed above, particularly Batteries, Electrification and Energy Efficient Mobility Systems. The reviewer added that inductive charging is the next step in fast charging, with the potential to fast-track widespread EV adoption.

Reviewer 2:

The reviewer noted that the project is relevant to the VTO Electrification subprogram as it is designing and developing a plug-less extreme fast charging system that would enable faster and broader transportation electrification.

Reviewer 3:

The reviewer remarked that the Electrification Technologies (ELT) subprogram objectives in the linked Annual Progress Report focus on power electronic and electric motor cost (dollar/kilowatt) and power density (kilowatt/liter). The reviewer noted that the project's power electronics development resulted in a power density of 54.58 kW/L, exceeding the DOE 33 kW/L 2025 target. The reviewer added that the objectives do not specify wireless charging surface power densities (kilowatt/square meter) but Slide 9 of the 2022 presentation showed the significant increase from approximately 250 kW/m^2 to 1.5 MW/m^2 (vehicle side). The reviewer commented that the cost was not mentioned which will be critically important if this were to be offered on commercially available vehicles. The reviewer mentioned deeper collaboration with Volkswagen to understand how to further develop the prototype development into a potential commercial product at an OEM or tier supplier level.

Reviewer 4:

The reviewer observed the potential applications in fleets and public charging stations.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented that the presenter did not indicate the resources were insufficient to achieve the stated milestones; however, for this charging system to be marketable, much more testing and refining needs to be done, as stated in the presentation.

Reviewer 2:

The reviewer noted that the total project funding over a 5-year period of performance is $5.2 million of which DOE share is $2.2 million. The reviewer added that this funding amount seems appropriate for the proposed scope and approach of the project.

Reviewer 3:

The reviewer mentioned that the project involves component development like modeling and prototype hardware and software, testing, and vehicle integration work. The reviewer concluded that the funding level seems to be in line with the work included in the scope and the work that has been completed.

Reviewer 4:

The reviewer had nothing to note.

Presentation Number: ELT240
Presentation Title: Wireless Extreme Fast Charging for Electric Trucks (WXFC-Trucks)
Principal Investigator: Ryan Calder (WAVE, Inc.)

Presenter

Ryan Calder, WAVE, Inc.

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 67% of reviewers felt that the resources were sufficient, 33% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

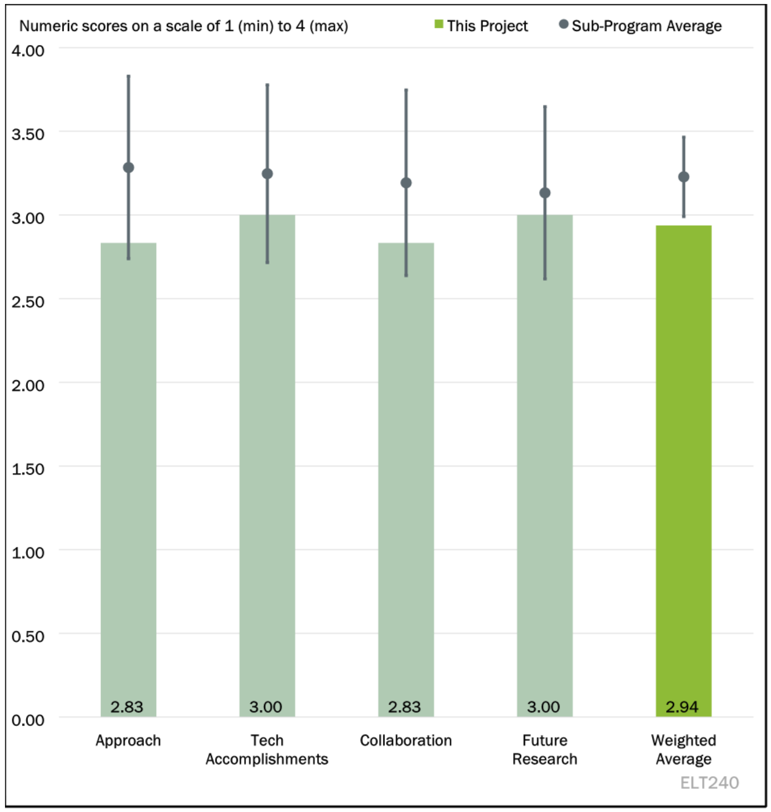

Figure 2-15 - Presentation Number: ELT240 Presentation Title: Wireless Extreme Fast Charging for Electric Trucks (WXFC-Trucks) Principal Investigator: Ryan Calder (WAVE, Inc.)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer commented that this expands the options for wireless power transfer (WPT) to the highest level identified in the standards and addresses the design, installation and system testing and some site issues. The reviewer noted that additional site options should be included to include more use cases that need to address challenges of this power level being used for multiple stations.

Reviewer 2:

The reviewer observed that the project briefing lists the following barrier: "Meeting the window of time to deliver a medium voltage feed to the charge site." The reviewer added that the project team has been unsuccessful in addressing this barrier and the project is in its final year of the project plan.

Reviewer 3:

The reviewer noted that the project is well designed for the total cost and expected work. The reviewer said that the timeline is an issue as delays in materials and siting permissions have lost the project valuable time. The reviewer declared that the overall milestones and corresponding budget period in which the milestones would be completed seem reasonable except for Task 6: 500 kW system deployment. The reviewer stated that while the timeline for this task spans all three budget periods, the project has less than six months to go, and the system still has not been deployed. The reviewer observed that the presenter was asked how the project team is addressing this barrier and responded with an answer that said that the testing would still span the original six months planned, though the reviewer was uncertain how this will happen unless there is a no-cost extension to the project.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer noted that the results identify that the goals are being met with charge rates and duration.

Reviewer 2:

The reviewer stated that this project appears to have accomplished some piecemeal testing of components but has been unable to create and demonstrate the original vision of a fully integrated MV grid connection with step-down to 500 kW wireless charging system at the port of Los Angeles facility that is used in a 2-year demonstration to charge two Class 8 trucks.

Reviewer 3:

The reviewer remarked that the technical accomplishments and progress have been affected by material and siting permissions delays but most assembly has been completed and testing of the unfolder, enclosures, transformers, and cabinet has begun. The reviewer declared that no unexpected issues seem to have come up. The reviewer added that software and control development on the low power prototypes appear to work as expected and demonstrated close to 50% reduction in total harmonic distortion.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer noted that the project has a sufficient mix of partners and good participation to meet goals, timing, and budget.

Reviewer 2:

The reviewer stated that testing accomplishments indicate some level of collaboration between partners but the lack of fully integrated demonstration suggests that collaboration could be improved.

Reviewer 3:

The reviewer observed that on the industry side, TTSI, the port trucks partner, has not seemed reliable, since the overall project team is unable to do site deployment according to their original timeline. The reviewer added that while the presenter indicated the project team would be seeking out another port partner, it is very late into the project period to be needing to make the switch and onboard a new ports partner. The reviewer did not attend the AMR last year and was uncertain why Wireless Advanced Vehicles Electrification (WAVE), the project lead, waited so long before connecting with TTSI about the port location and permissions there.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer stated that more data from site variations could be used. The reviewer added that access to medium voltage issues at other sites needs to be included. The reviewer commented that additional testing for EMC/EMF and other factors could be included.

Reviewer 2:

The reviewer noted that future work listed is appropriate to complete the revised work plan.

Reviewer 3:

The reviewer expressed that future work is based on deploying the wireless charger and truck and demonstrating the AC/DC converter and seems reasonable to finish out the project. The reviewer added that future work will likely achieve its targets, just not on the original timeline, which was to run the demonstration for six months and collect required data.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer indicated that vehicles using higher power wireless charging offers a means for hands-free charging along with options for AC and DC charging.

Reviewer 2:

The reviewer confirmed that the project supports the overall VTO subprogram objectives to develop high power charging technologies for HD EV charging.

Reviewer 3:

The reviewer noted that the project is relevant to all categories of VTO. The reviewer added that the project focuses on creating better HD EVs through fast wireless charging. The reviewer stated that materials are affected by what the wireless chargers are made out of, and the electric powertrain created specifically for this project by Cummins as well as the auto charge testing system, and creation of custom thermal management for cell fast charging. The reviewer reported that Energy Efficient Mobility Systems can review the data from the bus wireless charger and gain insight into efficiencies and improvements in existing mobility systems. The reviewer remarked that since there is a custom Cummins electric powertrain, the advance engine and fuel technologies category is covered, as well as electrification and analysis through the final deployment and data collection.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that partners are well versed with the technology and effective to apply previous systems to this higher power approach.

Reviewer 2:

The reviewer said that it appears that the timeline allocations and the planning resources for this project were insufficient since the project plan was not executable in the planned timeframe. The reviewer indicated that it is clear that the budget was not sufficient to overcome the issues that were encountered.

Reviewer 3:

The reviewer expressed that for the total budget of the project, the resources seem sufficient for the project to achieve all their stated milestones in a timely manner; however, due to supply chain delays and site permissions delays, there will have to be a no-cost time extension to get the deployment and testing validated. The reviewer added that the amount of resources should have facilitated no time delay, but due to the project timeline spanning the Covid pandemic and the subsequent resource and supply chain delays, the project seems as on schedule as it could hope for.

Presentation Number: ELT252
Presentation Title: Wound-Field Synchronous Machine-System Integration toward Increased Power Density and Commercialization
Principal Investigator: Lakshmi Iyer (Magna Services of America, Inc.)

Presenter

Lakshmi Iyer, Magna Services of America, Inc.

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 50% of reviewers felt that the resources were sufficient, 50% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

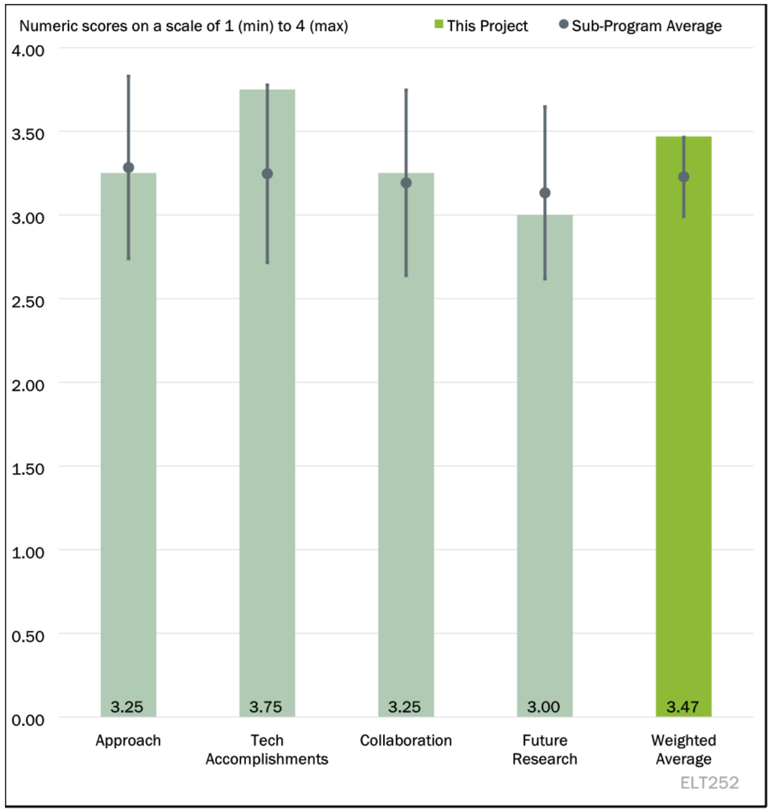

Figure 2-16 - Presentation Number: ELT252 Presentation Title: Wound-Field Synchronous Machine-System Integration toward Increased Power Density and Commercialization Principal Investigator: Lakshmi Iyer (Magna Services of America, Inc.)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer noted the nice work exploring novel motor design and the high potential for translation from university to industry.

Reviewer 2:

The reviewer stated that the investigators have done a very good job of looking at the design tradeoffs (cooling, manufacturing costs, etc.); however, using a World-Harmonized Light-Duty Vehicle Test Cycle (WLTC) based cycle for measuring efficiency could provide rather optimistic estimates of the e-machine performance. The reviewer added that using more aggressive cycles, specifically, the EPA 5-cycle may have given a better indication of the operating efficiency. The reviewer expressed that it would have also been good to understand if the optimization process yielded significantly different design choices when optimized with respect to a different set of drive cycles. The reviewer observed that it is understandable that standard drive cycles have to be used to evaluate the efficiency of these machines, but that no real customer drives these standard drive cycles, and some idea of how good the machine performs in real world conditions would be very helpful. The reviewer commented that another point that comes to mind is that the machine is designed to be operated at 400V nominal. The reviewer reported that most OEMs appear to be moving towards 800V in the near future, and an understanding of how much benefit that could have provided in terms of efficiency would have been helpful as well. The reviewer remarked that it would also have been good if the relative merits of brushless field excitation and brushed field excitation were explored, but it is understandable that it was not part of the scope because there is nothing novel in brushed excitation.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer acknowledged that the project seems to be on track.

Reviewer 2:

The reviewer observed that it appears that Magna has reached a stage in the development where it is ready to put this design into serial production, which is a good indication of the project's success.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer would like to see more industry leadership, and it appears that the most critical parts are done within the university.

Reviewer 2:

The reviewer stated that considering that the scope of the project was to develop a wound-field synchronous machine (WFSM), the choice of team members could not have been better, since both Illinois Institute of Technology and University of Wisconsin-Madison have had a history of working on wound field synchronous machines with inductive or capacitive excitation.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer stated that it looks like they are wrapping up in 2023.

Reviewer 2:

The reviewer noted that the project has been completed.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer said it was relevant to Electrification.

Reviewer 2:

The reviewer affirmed that from an OEM perspective, while the little bit of hit that will be taken because lower torque density is not desirable, the lower carbon footprint, supply chain reliability, etc., is very desirable. The reviewer reported that this approach does not provide a significant cost advantage over "conventional" integrated power module (IPM) designs. The reviewer added that if these get to a point where they offer a cost advantage over conventional IPMs, then the impact of this technology would be far more significant.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that the project is ending so there is no need to adjust anything. The reviewer would like to see these types of projects to go over $1 million.

Reviewer 2:

The reviewer noted that the project has been completed.

Presentation Number: ELT255
Presentation Title: Cost-Effective, Rare-Earth-Free, Flux-Doubling, Torque-Doubling, Increased Power Density Traction Motor with Near-Zero Open-Circuit Back-Electromagnetic Field and No-Cogging Torque
Principal Investigator: Jim Gafford (University of North Carolina, Charlotte)

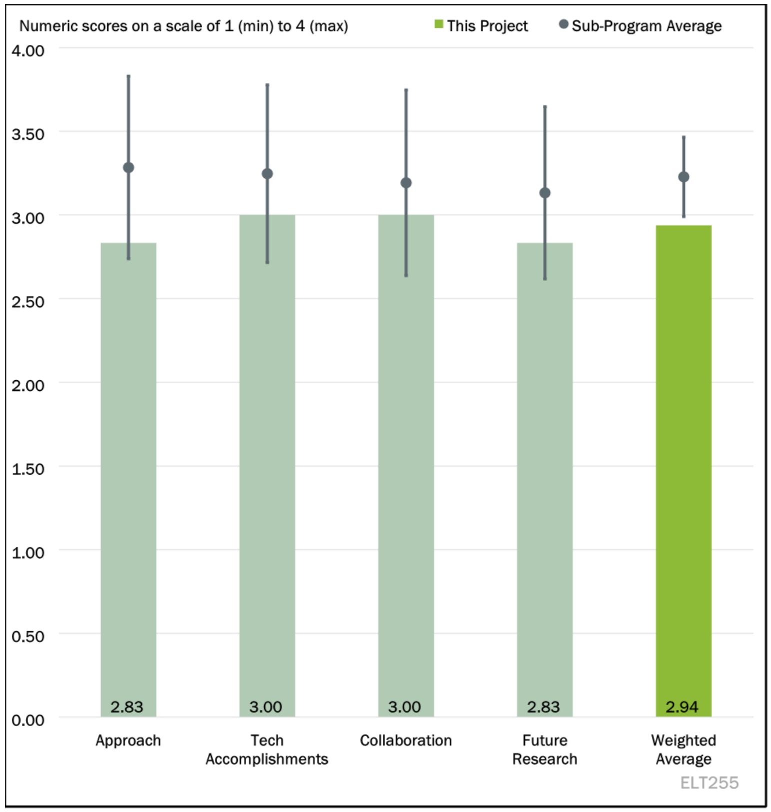

Figure 2-17 - Presentation Number: ELT255 Presentation Title: Cost-Effective, Rare-Earth-Free, Flux-Doubling, Torque-Doubling, Increased Power Density Traction Motor with Near-Zero Open-Circuit Back-Electromagnetic Field and No-Cogging Torque Principal Investigator: Jim Gafford (University of North Carolina, Charlotte)

Presenter

Somasundaram Essakiappan, QM Power, Inc.

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 67% of reviewers felt that the resources were sufficient, 33% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer remarked the project seems to be addressing and advancing towards overcoming the barriers.

Reviewer 2:

The reviewer commented since the project is timed to end in June 2023, the reviewer has not seen the quantified benefits of this project. Testing on a bench or dynameter was not well demonstrated.

Reviewer 3:

The reviewer said it is hard to draw conclusions regarding the performance of the proposed system with detailed test results as well as a quantitative comparison to a well-established baseline. Also, is the reported power density based on active material or total motor size?

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer remarked the project highlights good results and accomplishments.

Reviewer 2:

The reviewer said targets and objectives were not quantified in terms of actual performance in real world applications.

Reviewer 3:

The reviewer commented more complete test results including efficiency measurement are needed. Also, some cost estimate and information about magnet content should be provided.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer noted the team seems to be a small and efficient team. Good choice.

Reviewer 2:

The reviewer remarked a path toward commercialization was not demonstrated.

Reviewer 3:

The reviewer commented there seems to be good collaboration between participating organizations.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer remarked it seems like the team has plenty to do.

Reviewer 2:

The reviewer said the objective for cost reduction was not presented.

Reviewer 3:

The reviewer recommended more detailed experimental results are needed.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer agreed the project is relevant in terms of trying to meet the DOE targets.

Reviewer 2:

The reviewer noted the project is focusing on electrification.

Reviewer 3:

The reviewer noted this type of technology is widespread among key power electronics suppliers and it is becoming a commodity for electrified applications.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer would expect these projects to be over $1 million.

Reviewer 2:

The reviewer said the project seems to be sufficient for the scope of work.

Reviewer 3:

The reviewer found that resources are sufficient based on scope.

Presentation Number: ELT260
Presentation Title: Improving the Freight Productivity of a Heavy-Duty, Battery Electric Truck by Intelligent Energy Management
Principal Investigator: Teresa Taylor (Volvo Trucks)

Presenter

Teresa Taylor, Volvo Trucks

Reviewer Sample Size

A total of six reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 83% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 17% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

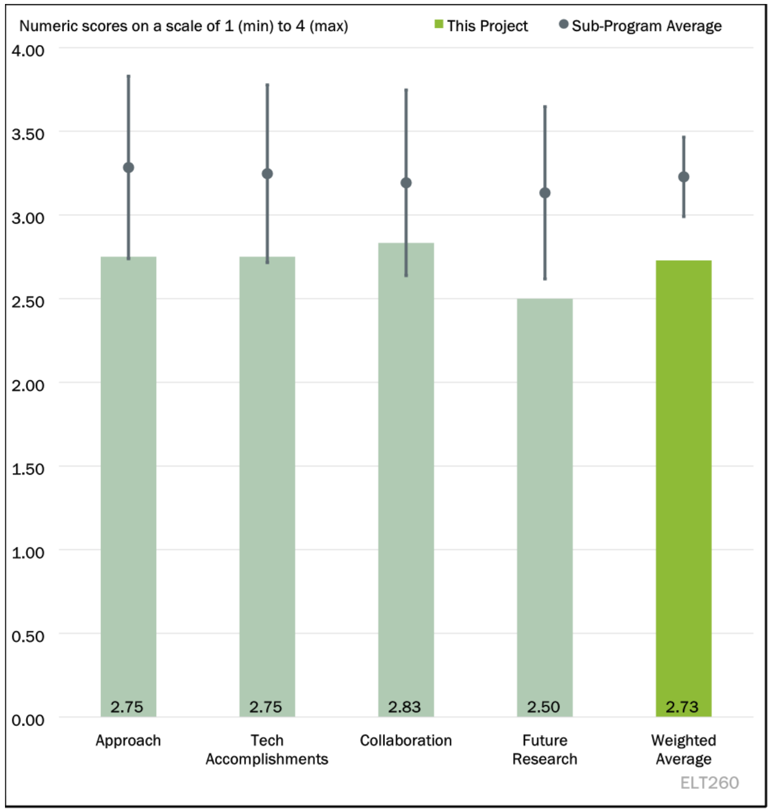

Figure 2-18 - Presentation Number: ELT260 Presentation Title: Improving the Freight Productivity of a Heavy-Duty, Battery Electric Truck by Intelligent Energy Management Principal Investigator: Teresa Taylor (Volvo Trucks)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer commented it does not seem to be a well-managed project. The reviewer did not see much of “new” things from last year, and University of Minnesota appears to be doing all the work.

Reviewer 2:

The reviewer said it is unclear how the proposed work will validate the improvements relative to other tools which may be available and as compared to the baseline of status quo. This should be made clear and must consider real-world application and benchmarking in some form.

Reviewer 3:

The approach was good for this project. Having said that, the reviewer is not convinced of the execution.

Reviewer 4:

The reviewer said the project is updated from actual data but may not address variations to vehicle weight as lighter versus heavier loads are included. Optional routes may not be as effective if destinations are shorter distances and vary daily.

Reviewer 5:

The reviewer said this project addresses Improving the Freight Productivity of a Heavy-Duty, Battery Electric Truck by Intelligent Energy Management. The barriers that were considered were TCO including the high purchase price and range of charge and payload, lack of valid performance and reliability data on battery electric trucks in real-world usage, and infrastructure planning and costs. The 3-year project was designed to first understand the fleet partners' baseline operations and establish project duty cycles and then develop a physics-based truck model that would combine battery information, utility demand charges, and database parameters as inputs to a machine learning algorithm that will predict energy use, operational energy cost, and battery performance. Implement an intelligent energy management system installed on two battery EVs using a low low-distraction screen to display charging and routing recommendations to operators along with vehicle charging stations at fleet partners' locations. The reviewer said a final analysis of the data generated was used to compare battery electric trucks and validate the intelligent energy management system for an extended mileage range. This is considered an outstanding approach to addressing the barriers identified.

Reviewer 6:

The reviewer noted the major problems still to be attacked in this project are as follows: (1) determine the mass of the actual payload—this is critical for the algorithm for the intelligent energy management system (i-EMS) to work; (2) take into account real-time traffic conditions, detours, and routing changes, and (3) feasibility/ viability of the driver-vehicle interface (DVI) is critical for reducing range anxiety). The reviewer said the project also failed to take into account the amount of time for in-route charging; although this is controlled by the charging management system, it has to be factored into the total cost of operation because the driver has to be paid while waiting for the charging to be completed. Emissions reduction should never have been an issue in this project.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer remarked the project is progressing satisfactorily relative to overall plans. No lapses in technical progress relative to planned milestones are identified.

Reviewer 2:

The reviewer observed some good accomplishments; however, the project is lacking highlights of the latest updates (i.e., What's new?). The reviewer noted the project is going to end soon, no need to correct the course.

Reviewer 3:

The reviewer said there are many deliverables yet to be completed—and this team is now out of time—as the project ends this month. The calculation to determine mass appears to have worked very well.

Reviewer 4:

The reviewer said results are early since vehicles and charging equipment have not been fully implemented.

Reviewer 5:

The reviewer said one technical accomplishment was the development of a physics-based model that included algorithms for road load and battery capacity management. The model was tuned for the best fit of available trip data for regenerative braking, auxiliary power, and overall trip efficiency. The model is capable of predicting linear travel range assuming similar energy consumption and charging needs including average energy consumption (kilowatt-hour/mile). The reviewer noted the team used recurrent neural networks to predict energy needed to complete route and trained using historical driving data and route information. The team also used mass prediction to monitor energy consumption for both the observed and modeled conditions. An economy toll estimation was developed by matching global positioning system trajectories to paths in a road network graph which provided travel features on each segment of road network graph. The reviewer said an energy efficient routing pathfinding algorithm was developed that used a physics-informed heuristic approach with pre-calculated energy consumption for all segments in all situations. The algorithm supported multi-destination routing and accounted for road restrictions, which is better than the current state-of the-art models that attempt to do this. Another technical accomplishment was to determine the placement of charging station for commercial fleets by collecting driving data for existing fleet routes, simulating the fleet routes using the tuned battery EV model, predicting the charging demand along the road network, and optimizing the charger sizing and placement to meet charging demand considering time, cost, and route coverage. An operational cost model was also developed that contained data for fixed costs, materials, charger hardware, electrical hardware, variable costs, labor and maintenance, taxes and permit fees, energy, the number and cost of trucks, the number and cost of chargers, and the energy costs (electricity or fuel). This is considered to be a very comprehensive model for the application to battery EVs. All these technical accomplishments are considered to be significant contributions to further the acceptance of EVs.

Reviewer 6:

The presentation points out that 80% of the project has been completed, but honestly, absolutely no milestones were given so it is impossible to determine whether 80% of the tasks or effort required to complete the project have actually been completed. Considering the fact that the end date of the project is June 2023 (two weeks away), the in-route charging equipment has not been installed in the second location (Texas), the Texas data has not been collected yet, this project is behind schedule. With an end date of June 2023 and start date of October 2019, the project should have been more than 90% completed.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer remarked the collaboration included academia (University of Minnesota), an EV charger supplier (Gilbarco), and two fleet operators (HEB Companies and Murphy Logistics) led by the original equipment operator (Volvo). This is considered excellent collaboration for the purpose of generating real world data that was used in the model development that will be beneficial to the manufacturers and operators.

Reviewer 2:

The reviewer liked the fact that an actual trucking company is demonstrating or testing the battery-electric tractors as well as the field i-EMS algorithm. The reviewer also appreciated the fact that the drivers were interviewed about how they like the battery-electric trucks and about range anxiety.

Reviewer 3:

The reviewer noted that the University of Minnesota appears to be doing the majority of the work.

Reviewer 4:

The reviewer remarked team collaboration needs to be demonstrated more clearly. Specific contributions of partners are not clearly demonstrated.

Reviewer 5:

The reviewer noted that when a project is running this far behind schedule, one has to wonder if a lack of coordination is partly to blame.

Reviewer 6:

Fleet partners should be included to provide a variation of feedback on results.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer said the project is ending soon, so future work is somehow less ambitious. Also, the project appears to be more complex than the team can handle.

Reviewer 2:

The reviewer said proposed future research should increase validation with focus on real-world conditions.

Reviewer 3:

The reviewer found that the proposed future work is in line with the original project plan. Having said that, the reviewer did not see how this can be completed within the original timeframe.

Reviewer 4:

The reviewer pointed out that more locations with variations on loads, terrains, traffic, etc. will broaden the data model.

Reviewer 5:

The reviewer commented that although the project has ended, the proposed future research recommended extending test routes with the addition of an on-route charging station, demonstrating a capability to achieve 250+ miles of daily driving, evaluating eco-routing algorithms for test routes, finalizing the cost model and evaluate the return on investment and emission reduction, and evaluating the impact of extreme ambient conditions (hot summer and cold winter geographical locations) on performance. These seem to be reasonable follow-on efforts to this project.

Reviewer 6:

The reviewer commented the principal investigator still needs to address the mass (payload) determination, dynamic re-routing due to traffic, detours and construction, and suitability of the DVI. Emissions reduction should never have been an issue.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer remarked there are very few projects for HD battery EVs, so this project is commendable.

Reviewer 2:

The reviewer noted the project's relevant to Analysis and Electrification.

Reviewer 3:

The reviewer said the basic program objectives are satisfied.

Reviewer 4:

The reviewer commented the project scope is certainly relevant to VTO objectives. The reviewer was just not sure the project completed enough of the original objectives to offer much new technical knowledge.

Reviewer 5:

The reviewer remarked this project provides initial input to the data required.

Reviewer 6:

The reviewer said this project fully supports the Electrification R&D Grid and Charging Infrastructure program's mission to conduct early-stage research and development on transportation electrification technologies that enable reduced petroleum consumption by light-, medium-, and HD vehicles.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said for what was done the funding appears to be sufficient.

Reviewer 2:

The reviewer said resources for this project were aligned well with the original project scope.

Reviewer 3:

The reviewer said this project was funded $4.9 million over a 4-year period or more than $1 million per year with a 25% cost share by industry. The companies involved for the funding allocated provided sufficient resources for the work required.

Reviewer 4:

The reviewer recommended variations to charger sizes at various locations are needed because 150 kW is the low end of the power expected.

Reviewer 5:

The reviewer commented project resources appear higher than would be expected but the industrial cost share does offset some concerns.

Presentation Number: ELT261
Presentation Title: High-Efficiency Powertrain for Heavy-Duty Trucks using Silicon Carbide Inverter
Principal Investigator: Steve Peelman (Ricardo)

Presenter

Steve Peelman, Ricardo

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 67% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 33% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

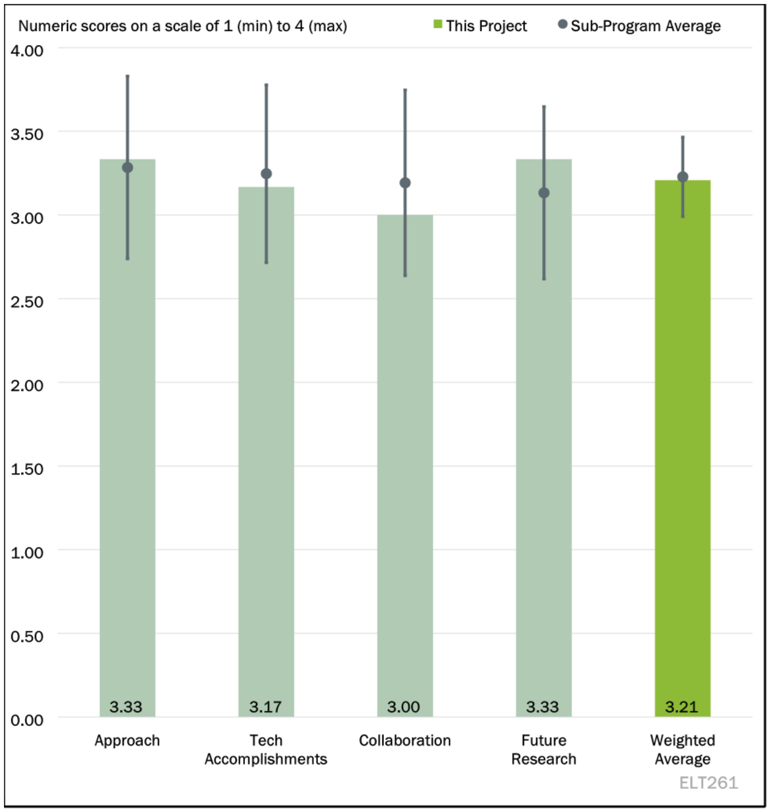

Figure 2-19 - Presentation Number: ELT261 Presentation Title: High-Efficiency Powertrain for Heavy-Duty Trucks using Silicon Carbide Inverter Principal Investigator: Steve Peelman (Ricardo)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer remarked attention to the performance and efficiency of electric drive components is valid and important to achieve maximum feasible range/cost from energy storage system (ESS) and reduce overall energy consumption costs. The evidence of project outcomes would be improved when vehicle level results of ton-miles/kWh are presented and compared to the baseline.

Reviewer 2:

The reviewer commented the project report outlines a logical and appropriate approach to execute project tasks targeted for the successful completion.

Reviewer 3:

The reviewer remarked the project does not appear to be addressing major technology challenges. This project is more on a demonstration side.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer said that the development and tests of the new inverter, with data shown, are significant. The presentation would be stronger with short notes on the key technical aspects of the SiC inverter that made it more efficient than the baseline inverter. This was probably shown in detail in prior years, but a short review would be constructive here. The reviewer recommended the baseline technology should be clarified, and how long the SiC inverter has been used in this application should be mentioned.

Reviewer 2:

The reviewer said cannot really point out anything going above or beyond what was promised. The project is mainly addressing component development.

Reviewer 3:

The reviewer remarked the packaging improvements for inverter power stage has led nearly 3% improvements in partial power efficiency, which is significant as majority of the time SiC and even Si insulated gate bipolar transistor (IGBT) inverter in vehicles operates at partial load. Motor is characterized in back-to-back motor dynamometer. The reviewer reported that the current controller was tuned for faster dynamic response over the loading condition of the SiC inverter and that five vehicles are built for testing.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer commented that excellent collaboration exists in executing the project activities.

Reviewer 2:

The reviewer said the project partners are shown as having complementary roles, but details are not strong. It is not clear which if any partners are in business of large-volume production of inverters. The reviewer said further explanation is needed.

Reviewer 3:

The reviewer noted that it looks like North Carolina State is doing a lot of work, but the overall collaboration appears to be going well.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer remarked continuation of the project to an on-road assessment is appropriate and presented adequately. The presentation of the significant remaining challenges indicates high degree of team strength.

Reviewer 2:

The reviewer commented that the project is wrapping up so no need to direct any further.

Reviewer 3:

The reviewer said this project is about to conclude, and a project report included future research task and topics, which are relevant and appropriate for remaining time in the project, which may be no-cost extension-type situation.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer remarked that the improvement of electric drive component and system efficiency is highly relevant to making EVs cost competitive for an accelerated decarbonization strategy.

Reviewer 2:

The reviewer noted the project focuses on electrification.

Reviewer 3:

The reviewer commented that this project is relevant to VTO sub-program in electrification area and will accelerate adoption of on-road HD such as trucks and buses.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said it would be useful to present the funding distribution among the partners.

Reviewer 2:

The reviewer commented that the project is about to wrap up. The 20% cost share is a very good ratio for this kind of development project, which could have been funded internally.

Reviewer 3:

The reviewer pointed out that the project PI is planning to request no-cost extension and the project has necessary resources and research funds.

Presentation Number: ELT262
Presentation Title: Long-Range, Heavy-Duty Battery-Electric Vehicle with Megawatt Wireless Charging
Principal Investigator: Ryan Reed (Kenworth)

Presenter

Ryan Reed, Kenworth

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 25% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

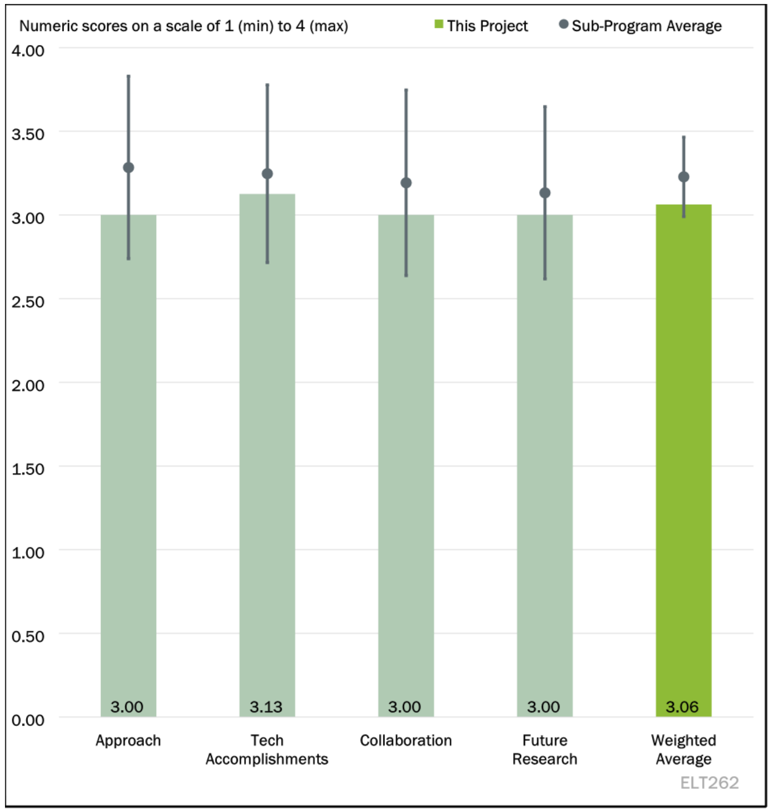

Figure 2-20 - Presentation Number: ELT262 Presentation Title: Long-Range, Heavy-Duty Battery-Electric Vehicle with Megawatt Wireless Charging Principal Investigator: Ryan Reed (Kenworth)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer said the goals and timeline of this project are well designed and in support of not only DOE goals, but customer goals and expectations for battery electric trucks.

Reviewer 2:

The reviewer stated comprehensive approach focusing on the wireless megawatt charger followed by truck design to incorporate megawatt charging technology and a 3-month test of the system in the fleet to demonstrate capability of 400-mile two shift operation.

Reviewer 3:

The reviewer noted this project is already in year four of a 5-year project. There have been many setbacks resulting in delayed deliverables. The reviewer said it appears that some of the initial work was likely slow getting started, pushing many deliverables to the end of the 5-year timeframe.

Reviewer 4:

The reviewer was not clear why 1 MW was selected, and said component efficiencies were also not explained, therefore no comparison is included on the project goals or results/improvements.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer pointed out that successful test of vehicle safety systems, optimization of electrical systems and components to maximize efficiency, and DCFC charging, and 1,800 miles of vehicle testing have been concluded. Additionally, wireless charger development is progressing with some supply chain challenges.

Reviewer 2:

The reviewer said it is unfortunate that the charge site needs relocating since that represents a setback to the timeline. Also, it would be good to see how the truck sub system efficiencies are being tracked for progress, i.e., traction motor, steering etc. The reviewer said it is commendable the project will be compared to a kilowatt/hour earlier generation battery electric truck.

Reviewer 3:

The reviewer noted this project has suffered several setbacks—both with the vehicle and wireless charging components. Having said that, the team continues to press on towards the final goal. Real world verification of modeled systems is essential as our society moves towards battery electric vehicles (BEVs).

Reviewer 4:

The reviewer was unclear how this project impacts increasing BEV range other than the one objective to "add 170 miles of range" (to support a 400-mile total) with a 30-minute charge. The base BEV statistics need to be explained and a comparison chart would help clarify this projects goals and results.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer remarked the project team includes a balanced and complete team.

Reviewer 2:

The reviewer said that although somewhat behind due to problems and charge relocation, it sounded like the team is making progress and still plan to finish on time.

Reviewer 3:

The reviewer said a broad team of partners covering all relevant areas for a successful technology development and demonstration was initially assembled. Kenworth is the prime applicant and truck OEM, United Parcel Service as an end user fleet, WAVE as the wireless technology company and Utah State University who has been leading wireless technology research over the past decade. The two local utilities in Washington and Oregon state originally participated as demonstration locations; since demonstration is shifting to Utah, the team is working on onboarding new utility partner, which could cause a potential scheduling delay.

Reviewer 4:

The reviewer was unable to determine from this presentation how well the team has actually worked together. The reviewer wondered if some of the initial delays were caused by poor team coordination. There was insufficient detail given in the presentation to determine all of the causes for delay.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

Although not specifically addressed, the reviewer assumed the listing of challenges would represent areas of needed future research and development.

Reviewer 2:

The reviewer remarked the future work identified is in line with the original project plan. Having said that, this team has an uphill battle to complete everything in a timely fashion.

Reviewer 3:

The reviewer said the period of performance extension through June 30, 2024, will hopefully allow for 3 months of in-use demonstration to be completed by UPS drivers. Next milestones are a full-scale demonstration of megawatt wireless charger system off-vehicle and installing the system on vehicle and at two demonstration locations. The reviewer said motor/transmission challenges due to early prototype with demonstration location shifting from flat northwest route to a hilly Utah route could pose additional challenges to a successful in use demonstration.

Reviewer 4:

The reviewer said accomplishments identify several vehicle and charger systems that are not explained in this presentation. Perhaps more detail of what was accomplished with Safety, Fault handling, thermal, charging control, etc. can be summarized or may need further research to identify how these were improved.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer said electric Class 8 truck zero emission technology development and demonstration directly supports the objectives of the VTO Electrification subprogram.

Reviewer 2:

The reviewer believed this project is highly relevant to the DOE programs and hope that the learning of the wireless charger will be shared as soon as possible to help move that protocol forward for customers.

Reviewer 3:

The reviewer noted that extended range operation and wireless charging are both topics of interest for VTO. The reviewer wondered if this project should have actually been two separate projects.

Reviewer 4:

The reviewer remarked higher power is expected but this project still does not identify why 1MW was selected vs. others.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said no resource problems were identified by the project.

Reviewer 2:

The reviewer commented the participants satisfy the various categories required to accomplish a complete summary of the project.

Reviewer 3:

The reviewer said $8.6 million project with $5 million DOE share seems appropriate for a 5-year development and demonstration project of a new HD Class 8 truck propulsion system and charging technology.

Reviewer 4:

The reviewer remarked this is a very large project—maybe should have been split into two separate projects. The reviewer was not sure if more funding would have been helpful, but it might have.

Presentation Number: ELT264
Presentation Title: Demonstration of Utility Managed Smart Charging For Multiple Benefit Streams
Principal Investigator: Stephanie Leach (Exelon/Pepco Holdings, Inc.)

Presenter

Stephanie Leach, Exelon/Pepco Holdings, Inc.

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

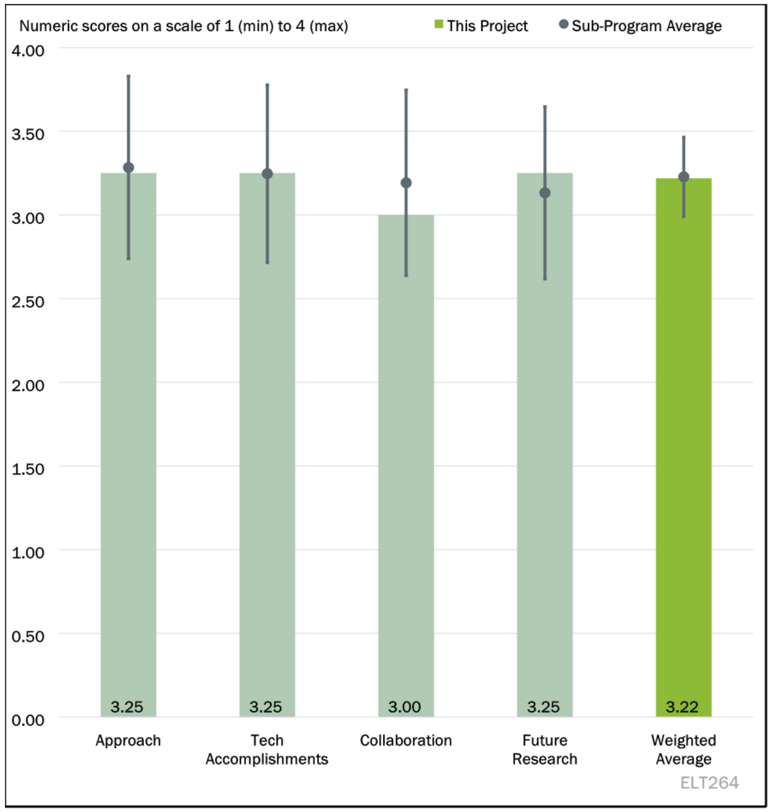

Figure 2-21 - Presentation Number: ELT264 Presentation Title: Demonstration of Utility Managed Smart Charging For Multiple Benefit Streams Principal Investigator: Stephanie Leach (Exelon/Pepco Holdings, Inc.)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer noted this is year three of a 4-year project. The 2023 "Barriers and Technical Targets" are completely different than in 2022, so the reviewer was unsure if the project focus had changed with DOE approval. The contract end date is noted on Slide 2 as December 2024, but Slide 4 mentions work being completed in March 2025. The approach seems to be logical and the presentation style (Slide 5; colored boxes, lines linking Objectives to Expected Outcomes/Milestones) is simple and effective.

Reviewer 2:

The reviewer said the project appears to focus on the mechanics of a smart charge management (SCM) prototype capability in the context of a low EV penetration environment where there is sufficient grid capacity to meet EV charging demand. The PI's response to reviewer questions regarding quantification of EV consumer costs indicates that there have been insufficient considerations of the metrics for trade-offs to be made when charging demand saturates the capabilities of the grid and some charging needs go unmet. The high penetration scenario mentioned will likely introduce saturation conditions which deserve more robust metrics to unlock the value of this project.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer remarked the project schedule shows that significant progress has been made to implement the project plan.

Reviewer 2:

The reviewer said progress looks to be significant among the different efforts and partners. The details on Slides 6–7 are clear using the same presentation method as the approach summary. based on the Slide 4 schedule it seems like the project is on track. However, having all of the 2023 milestones for December 31, 2023, seemed odd to the reviewer given DOE may require at least one milestone per quarter. The reviewer observed each milestone may be for different team members' roles, but having multiple milestones along the way for each would make sense for the project team and DOE to more effectively manage progress to make sure no surprises arise. The reviewer notes the progress on all sub-efforts (smart charge management [SCM] demo, Agent-based Transportation Energy Analysis Model [ATEAM] modelling, ATEAM Transmission Distribution [ATD] modeling).

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer remarked the teaming between Exelon (Baltimore Gas and Electric [BGE] and PECO) with Argonne National Laboratory (ANL), Weave Grid (telematics), and EVSE/charging network service providers (Shell Recharge Solutions and EVmatch) seems to be a logical and complementary combination of expertise. Project roles are clear given the organization's expertise and functions. The details by effort listing organizations that are supporting is very clear. The project seems to be well-coordinated with defined tasking and information handoffs between the sub-efforts.

Reviewer 2:

The reviewer said this project would benefit by increasing the collaboration between the ANL modeling team and the project lead so that the full implications of grid resource constraints can be addressed.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer commented proposed future work is to accomplish the remaining project scope, so it is logical.

Reviewer 2:

The reviewer said future work makes sense to complete the grid mechanics focus of the pilot.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer remarked the project is highly relevant to the Electrification subprogram objectives to develop and demonstrate smart charge management (SCM) capabilities that can help mitigate the impact of EV charging on the electric grid.

Reviewer 2:

The reviewer commented very relevant project to DOE goals and the utility industry's needs to develop technology/behavioral approaches to manage power demand for grid health. The project is developing/conducting a SCM demonstration across different customer types (residential, commercial and public) to develop optimal managed charging approaches for the grid. The project is also evaluating the impact of wide-scale EV charging on utility distribution operations and evaluate the ability to control EV charging load based on grid conditions.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented DOE funding role in the project seems to be adequate. The cost shared funds are likely to fund partner roles since it is expected Exelon's investment was per the Maryland Public Service Commission approved budget. If so, this all makes sense.

Reviewer 2:

The reviewer remarked the accomplishment of project milestones to date suggests that there are sufficient resources to achieve all the project milestones.

Presentation Number: ELT265
Presentation Title: A Secure and Resilient Interoperable SCM Control System Architecture for Electric Vehicles-At-Scale
Principal Investigator: Duncan Woodbury (Dream Team LLC)

Presenter

Duncan Woodbury, Dream Team LLC

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

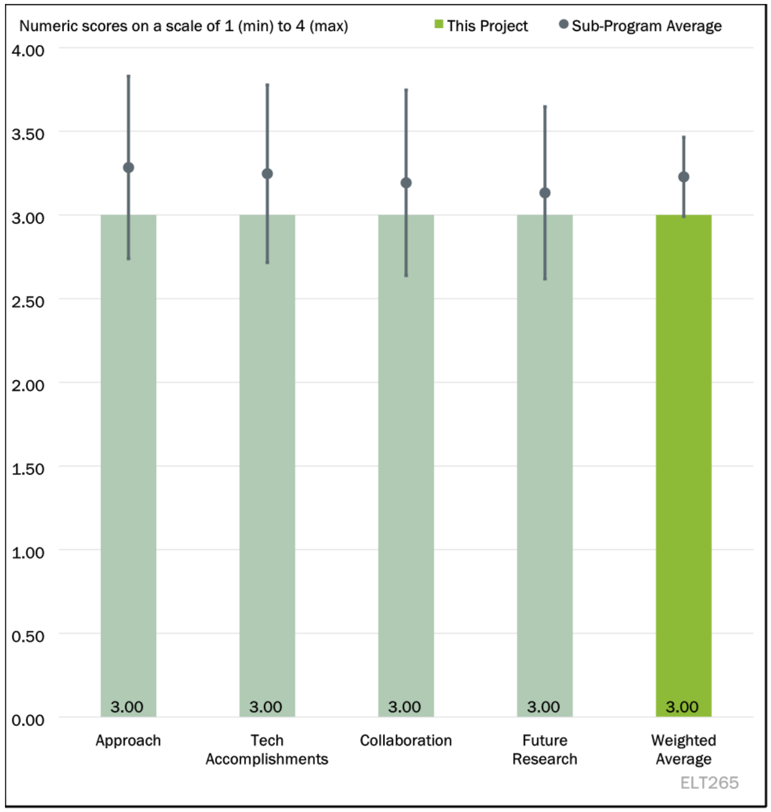

Figure 2-22 - Presentation Number: ELT265 Presentation Title: A Secure and Resilient Interoperable SCM Control System Architecture for Electric Vehicles-At-Scale Principal Investigator: Duncan Woodbury (Dream Team LLC)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer detailed EVs-at-RISC is targeting an open-source, open standards based SCM system for distribution networks with support for interoperable, secure management and grid integration of EVs, EVSE, and distributed energy resource (DER) EVs-at-RISC will not create new standards nor protocols, but instead is developing an approach to map existing standards back to International Electric Code (IEC) 61850/common information model (CIM). The system is professed to be applicable for vehicle grid integration (VGI), as well as vehicle to grid (V2G). This project has undertaken an innovative strategy to achieve its aggressive objectives. It includes implementation of a universal grid edge protocol through the extension of open field message bus (OpenFMB); hosting distributed public key infrastructure policy tools, and deployment in a zero-trust middleware layer; and leveraging external “oracles" to provide control triggers for grid automation. Overall, the reviewer remarked this is a very innovative and aggressive approach which, if successful, would significantly advance and potentially enable widespread implementation of flexible utility SCM systems across a wide variety of utility stakeholders, system architectures, and technologies.

Reviewer 2:

The reviewer said the approach is yet to be tested on large scale and with smart grid interface.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer said the project has demonstrated significant progress, technical accomplishments, and advances in technology readiness levels over the last year. Essentially all major tasks and achievement of milestones (including year 1 go/no-go) are successfully completed or on schedule. This includes: (1) Successful multi-protocol to OpenFMB adaptation validated for data normalization to IEC 61850/CIM allowing multiple vendors to be used; (2) Multiple site integrations within the EVs-at-RISC platform, and; (3) A multiple-site SCM demo over distributed networks with important use cases demonstrating achievement of key metrics therein.

Reviewer 2:

The reviewer said the project is still in the development stage and needs to consider a large-scale smart grid utility interface and a standard protocol similar to that of EPRI.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer suggested the project coordinate with EPRI for their experience in smart grid V2G.

Reviewer 2:

The reviewer commented that Liberas has assembled a strong, diverse team including a utility, national laboratories, transportation development center, security firms, university, and a non-profit. There are no apparent gaps in the team structure as all elements of RDD&D, including extensive demo sites and cybersecurity, are covered.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer said the team needs to expand the test cases and consider a common protocol among the utility providers.

Reviewer 2:

The reviewer remarked the project R&D is largely complete, and the effort is preparing to enter wide-scale demonstration and will deploy its platform across live distributed EVSE/DER networks. It will demonstrate production use of the platform for smart charging and distribution system operator/independent system operator grid services. The project is also focusing on reducing the "distance to integrate" and becoming truly seamless. This is excellent.

However, the project presentation mentions significant challenges therein including unique integration challenges, and regulatory and cybersecurity compliance barriers. Further elaboration of these areas would be beneficial. For example, the reviewer cited are there any potential showstoppers and how exactly does the variety and diversity of sites present unique integration challenges? Finally, are there any other unique business or commercialization barriers to widespread commercialization of the EVs-at-RISC platform? If so, how will the system specifically demonstrate enough value to overcome these barriers and what are the metrics for success?

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer said the project needs to have a common protocol among the grid companies.

Reviewer 2:

The reviewer pointed out that without adaptable, commercially viable SCM systems, utilities will have to invest much more heavily in infrastructure build-out and capability upgrades to meet electricity demand from EVs. This will substantially increase costs, ultimately being passed onto the consumer, and hinder the progression of widescale EV implementation and vehicle-grid integration.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said resources seem to be okay.

Reviewer 2:

The reviewer said the resources seems sufficient and appropriate to successfully conduct the project and achieve project milestones. The current spend rate is on track corresponding to project schedule and progress, and the project has a strong cost-share of approximately 32%.

Presentation Number: ELT274
Presentation Title: eMosaic, Electrification Mosaic Platform for Grid-Informed Smart Charging Management
Principal Investigator: James Stoupis (ABB)

Presenter

Alex Brissette, ABB

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

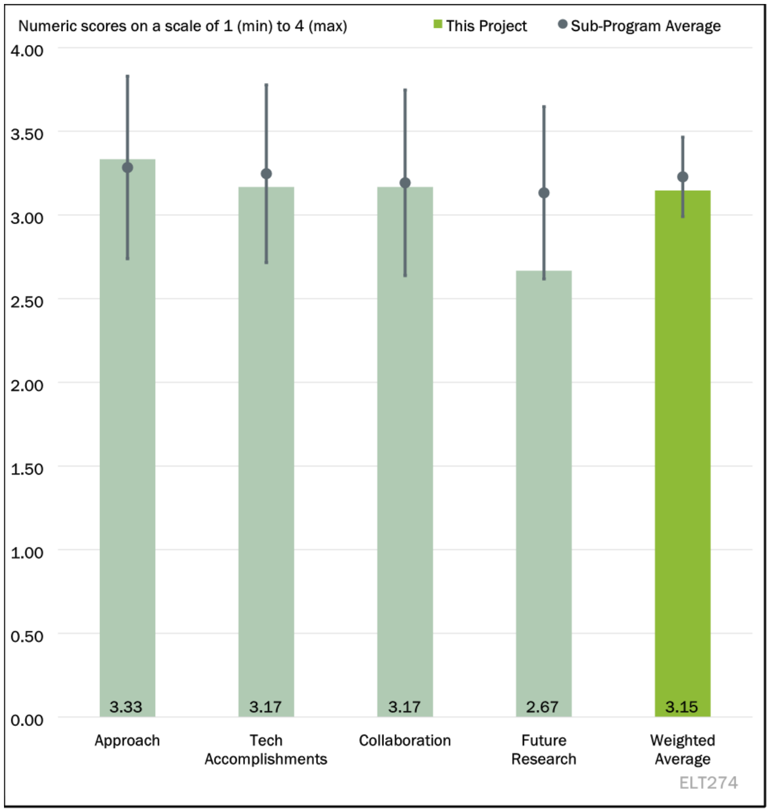

Figure 2-23 - Presentation Number: ELT274 Presentation Title: eMosaic, Electrification Mosaic Platform for Grid-Informed Smart Charging Management Principal Investigator: James Stoupis (ABB)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer noted that a few minor delays on subtasks have not affected the overall project schedule. With early phases complete, the project is ready for real-world demonstrations.

Reviewer 2:

The reviewer said the project's scope is relevant and has widespread applications.

Reviewer 3:

The reviewer noted that as presented, the approach appears sound and the project outlines a detailed task structure to meet its objectives. The reviewer very much appreciates the specific identification of evaluation criteria for each of the four demonstration cases. The barriers mention the desirability of a high level of interoperability. It is good that several tasks (e.g., 2.2.1, 3.1.3, and 3.1.5) specifically relate to interoperability. The reviewer assumes these "interoperability" tasks include the relevance of codes and standards and will consider their evolution moving forward and potential resulting impacts? Overall, it is important to clearly define project "measures of success." The PI indicated the following as "measures of success:" test procedures; getting to the point through testing in the field and addressing commercialization barriers—specifically grid-edge challenges such as sending data to the cloud with cybersecurity and the complications of open automated demand response (OpenADR). These seem important and broadly comprehensive and appear appropriate to emphasize as measures of success.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer remarked the demonstrations plans that have been developed cover a good range of use cases and should result in valuable findings when executed.

Reviewer 2:

The reviewer found that progress is on track.

Reviewer 3:

The reviewer said a solid and steady listing of technical accomplishments has been indicated through the task "tree" and milestone progress table. Tasks and milestones have been modestly delayed over the last year (approximately 6-month lag), but, in general, are steadily progressing. Budget period 2 go/no-go has been successfully completed. For demonstration cases 1 (dynamic pricing) and 2 (bus charge planning) it may be beneficial to consider additional evaluation elements. This could include socio-economic demographics with regards to dynamic pricing; and/or battery degradation and the impact on service personnel requirements as secondary issues for bus charge planning.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer said collaboration is on track.

Reviewer 2:

The reviewer noted the team is lean but sufficiently broad and diverse to meet project objectives and requirements. Team partners appear to be addressing and conducting appropriate roles and responsibilities. While it may be beneficial to add additional project participants, it doesn't really appear to be absolutely necessary.

Reviewer 3:

The reviewer said key team members seem to be working together well to execute plan. As noted by previous commenters, the team could be strengthened by more participation from EV network service providers (NSP). Most end users/sites host will not want to directly work with the utility but will want their NSP to do that.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer said the project is currently transitioning into a demonstration phase, which should help answer and validate many of the outstanding research questions. However, more specificity could have been added on future (beyond the project end) research.

Reviewer 2:

The reviewer said the project needs to consider large-scale data mining and varied test conditions.

Reviewer 3:

The reviewer noted that the team provided a solid listing of tasks for budget periods 3–4. The remaining challenges and barriers largely identify technical challenges and barriers. It would be beneficial to continue further strong consideration of the potential commercialization challenges such as interoperability, codes and standards, cybersecurity implications, and regulatory/policy evolutions and impacts. Plans to work through the

Utah State University network of Advancing Sustainability through Powered Infrastructure for Roadway Electrification (ASPIRE) Center parties for feedback is good and should be strongly pursued.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer said good testing of multiple smart charging use cases.

Reviewer 2:

The reviewer remarked as the electrification portfolio grows, the need for data management becomes critical.

Reviewer 3:

The reviewer agreed yes, the project is relevant. Without the availability of effective, commercially viable SCM systems, utilities will have to invest heavily in infrastructure and capacity upgrades to meet the electricity demand of EVs.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said the project seems to have been successful so far and is on schedule to complete its demonstration testing.

Reviewer 2:

The reviewer said resources are on track.

Reviewer 3:

The reviewer remarked the resources appear sufficient to meet the objectives and milestones as detailed in the project. The cost share (20%) is minimal, but adequate.

Presentation Number: ELT278
Presentation Title: EVs@Scale Lab Consortium
Principal Investigator: Andrew Meintz (National Renewable Energy Laboratory)

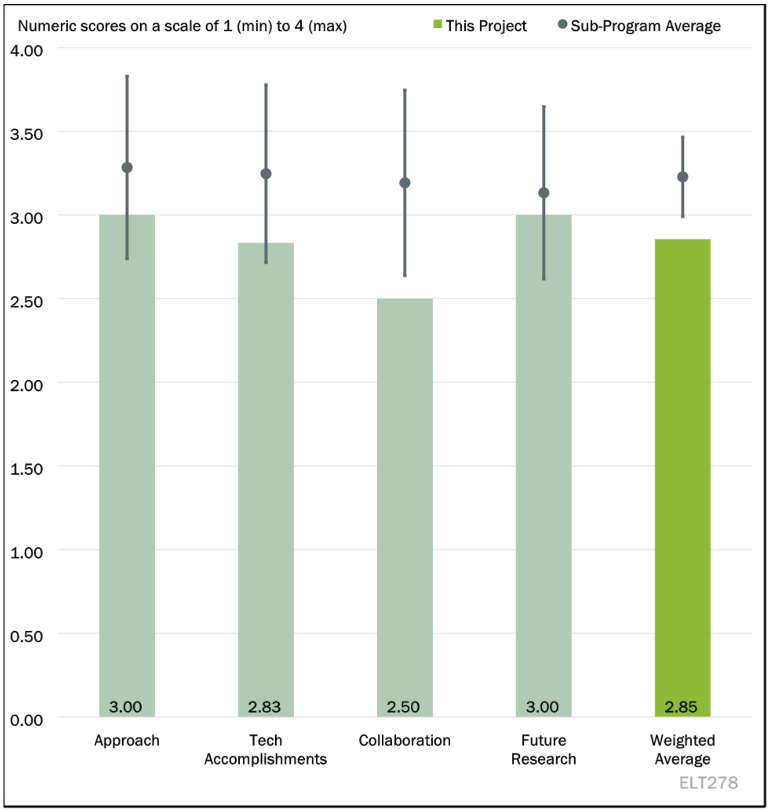

Figure 2-24 - Presentation Number: ELT278 Presentation Title: EVs@Scale Lab Consortium Principal Investigator: Andrew Meintz (National Renewable Energy Laboratory)

Presenter

Andrew Meintz, National Renewable Energy Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 67% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 33% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer said the consortium approach will enable the team to meet their objectives of develop plug-and-play solutions allowing a charging site to organically grow with additional chargers and DER through predefined compatibility with standards that will ensure interoperability and reduce upfront engineering expense. The team structure and participants are appropriate. This project will analyze and demonstrate Smart Charge Management and Vehicle Grid Integration approaches to reduce grid impacts from EVs@Scale, as a result of the charging needs of the on-road electrified fleet.

Reviewer 2:

The reviewer noted this is a difficult project to evaluate because it appears to me that each pillar could have been its own project since they appear to have only superficial if any inter-dependence. That said, the work within each pillar is generally well organized although it is not clear to me how this will translate into actual large-scale use. No timeline is specified and several of the outcomes are vague.

Reviewer 3:

The reviewer commented that the project is "way too large" in scale. The project should have been broken down into five separate projects according to the five pillars: Vehicle grid integration & smart charge management; high-power charging; wireless power transfer; cyber-physical security; and codes & standards. While there may be interaction or integration between the pillars, for the most part, they are minor and standalone (especially, wireless power transfer). There is no need to add another layer of management and oversight.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer noted that it is extremely difficult to link the objectives and outcomes to the milestones because the project plan is not given, the objectives and outcomes are very generally stated and insufficiently specific, and not all the milestones are given. Also, it is not possible to determine if a particular milestone was changed to avoid reporting a delay in progress. For example, for the VGI/SCM, the objectives were stated too generally and only three outcomes were identified: identify limitations and gaps in VGI/SCM; develop/demonstrate VGI approaches; and determine VGI and SCM benefits. These outcomes were not broken down into milestones and the milestones given in the presentation do not match/correspond to the outcomes given.

Reviewer 2:

The reviewer said all five pillars of the project have accomplishments. The SCM and VGI pillar has accomplished trip data acquisition and preprocessing. EV adoption modeling synthetic travel itineraries were validated against 2017 NHTSA vehicle trip distributions. For EV charging simulation, NREL research was used to simulate EV charging behaviors, energy demands, and infrastructure requirements. Generate location-specific load profiles is on-going work to assign charging demands to specific locations (e.g., land parcels) by location type. The High-Power Charging Pillar accomplishment was a 1000V, 175 kW Dual-Active-Bridge based charger was built and tested. The reviewer noted that for the Wireless Power Transfer Pillar, the team developed four devolved pre-cast concrete blocks, assembled four primary side power electronic units, which were tested and ready to be shipped. Also, two vehicle side units assembled and ready to be shipped. The Cyber-Physical Security Pillar developed the opportunity to map tools and capabilities to EVSE security functions and needs. The team also constructed a dynamic database for engaging with industry as well as ingested initial data from surveys. The Codes & Standards Pillar identified issues as well as standards, codes, and regulations that exist or are in development to address the issues. The team identified the gaps and recommended development of new or revised standards as well conformance and training programs, where needed.

Reviewer 3:

The reviewer said each pillar appears to have some accomplishments to share but again, given the lack of specificity on timelines or goals, it is difficult to know if the project is on plan.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer said coordination and collaboration across the national laboratories is acceptable, but the presentation did not list the private sector companies participating in this project. It is critical to know who is actively participating and whether they are providing significant input on this project. The utilities, EVSE and EV manufacturers, charge network operators (CNOs), standards development organizations (SDOs), other government agencies and infrastructure organizations, at least the major players if not all of them, have to be named for the reviewer to give credit for this question or criterion of evaluation. The reviewer suggests that people in the background, behind the scenes, who are supporting the project are neither acknowledged nor given credit for their contributions.

Reviewer 2:

The reviewer commented the project has a Stakeholder Advisory Group that includes utilities, EVSE & vehicle OEMs, CNOs, and SDOs. They are involved with government infrastructure direct interaction for each pillar projects. The team holds webinars/project discussions and semi-annual high-level meetings with all parties.

Reviewer 3:

The reviewer remarked most pillars could benefit from deeper industry collaboration to help shape the project and to help ensure that this work sees beneficial use. Only a few pillars mention any direct industry collaborators.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer said the proposed future research supports the overall goals of each pillar with several demonstration planned. The reviewer hopes the demonstrations in particular will result in interest and input from a broad group of industry participants.

Reviewer 2:

The reviewer found that proposed future research in the pillars of vehicle-grid integration & smart charging management, wireless power transfer, and codes & standards are satisfactory. However, proposed future research in the pillars of high-power charging and cyber security is unsatisfactory. For high power charging, the future proposed research does not match the identified remaining challenges and barriers. For cyber security, no future proposed research is addressing inconsistent implementation and utilization of latest security methods, recovery from adverse cyber events, training for the EV cybersecurity work force, lack of hardware to identify physical or cyber threats at charging stations, and transition to post-quantum computing cryptology.

Reviewer 3:

The reviewer remarked all pillars have work to do. The Smart Charge Management and Vehicle Grid Integration Pillars are conducting charging analyses on medium- and heavy-duty vehicles as well as co-simulation uncontrolled/controlled grid impact analysis. The High-Power Charging Pillar will perform evaluation and comparison of various site energy management system (SEMS) control algorithms with ESS and improving grid integration. The team is developing a universal power electronics regulator (UPER) (1000V class charger) with Spec-II module integration and evaluation with DC Hub—Develop impactful NextGen Profile analysis that can guide performance standards and inform industry from continued test execution and data gathering. The Wireless Power Transfer Pillar will conduct a 200 kW dynamic wireless power transfer (DWPT) demonstration in the field, and conduct comprehensive review of 200 kW DWPT system and identify gaps to deployment in real world cybersecurity. The Cyber-Physical Security Pillar will increase focus on electrified vehicles and charging infrastructure. The team will also focus on demonstrating high-power DC charging Infrastructure cyber-physical security mitigation solutions. Cyber Tools and Solutions for EVSE will open interface to industry solution providers. The Codes & Standards Pillar will finalize the megawatt charging system (MCS) coupler thermal-mechanical testing results report.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer said the EV and charging infrastructure industries are accelerating their activities. This speed requires quick action from the DOE and national laboratories to ensure our efforts remain relevant.

Reviewer 2:

The reviewer remarked the project supports the overall electrification objectives, albeit in ways that are difficult to measure or quantify.

Reviewer 3:

The reviewer would drop the wireless power transfer pillar. This concept is premature and irrelevant to contemporary needs.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said the project team does not identify any constraints that keep them from meeting their stated objectives.

Reviewer 2:

The reviewer remarked there appears to be sufficient funding for the next 4 years.

Reviewer 3:

The reviewer said this project is extremely similar to another project (the “GEMINI” project). The only difference is in the type of travel data used—agent-based or conventional travel profile.

Presentation Number: ELT282
Presentation Title: Technology & Design Innovations to Maximize the Reduction Effect on DCFC Unit Cost Economics (Max-REDUCE)
Principal Investigator: Robert Keefover (Borg Warner)

Presenter

Robert Keefover, Borg Warner

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

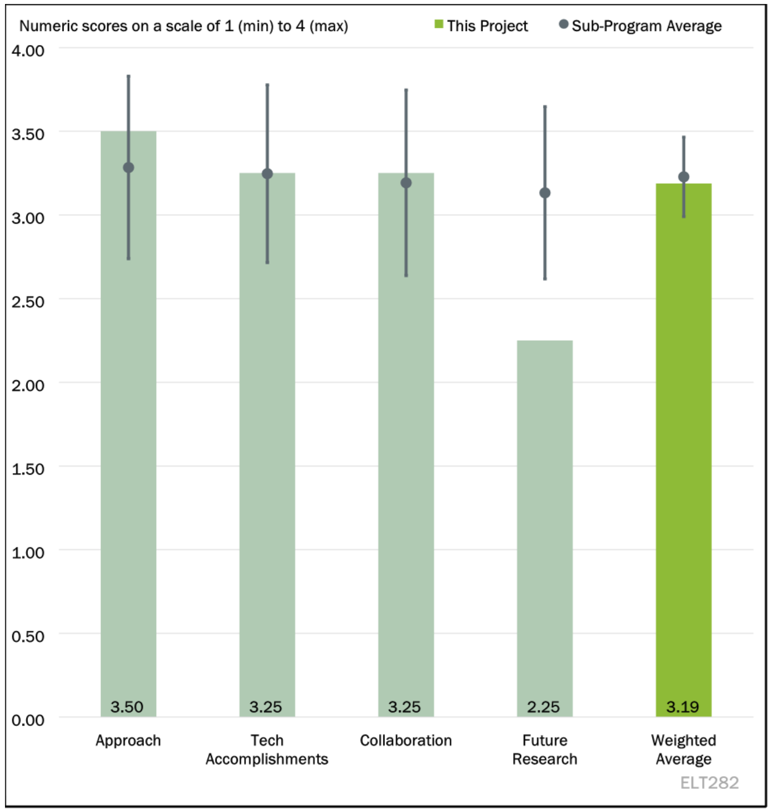

Figure 2-25 - Presentation Number: ELT282 Presentation Title: Technology & Design Innovations to Maximize the Reduction Effect on DCFC Unit Cost Economics (Max-REDUCE) Principal Investigator: Robert Keefover (Borg Warner)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer remarked the scope of the project addresses the technical barriers by focusing on power density, efficiency, interoperability, and reliability.

Reviewer 2:

The reviewer said the approach to using silicon carbide (SiC) power device rather than conventional Si-based power devices defies the goal for achieving an optimized cost. The Approach should consider a least maximum standardized maximum power up to 500 kW to enable achieving the goal of fast charging experience.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer remarked accomplishments clearly show the charger architecture functionality through modeling and simulation. Additionally, a 5 kW proto-type unit is ready for testing.

Reviewer 2:

The reviewer said the hardware evaluation is not yet demonstrated with the intended max power design.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer said a good collaborative team has been assembled to enable a successful project.

Reviewer 2:

The reviewer commented industry input seems to be less evident especially taking into consideration the exiting charging infrastructure and industry standards SAE J 1772.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer said the plan for the goal to achieve max power design and testing is not evident.

Reviewer 2:

The reviewer remarked t is unclear if the future scope is a significant change from the current project scope. The Relevance slide indicates 150 kW "….modular, single stage …DCFC… w/ unit cost reduction of more than 20%; and minimum 97% efficiency." In the summary slides, the table indicates the baseline is a "bi-directional" charger. A "uni-directional" charger is indicated as the intermediate step with significantly lower part count, and the end goal (highest efficiency, highest power density, and lowest cost) is shown as "new bi-directional design." Is the future project scope focused on developing a 60 kW bi-directional charging or a 150 kW unidirectional DCFC? The reviewer said this definition of project design target should be clarified at the beginning of the presentation.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer said this project supports the objective by reducing costs and improving efficiency of EV charging infrastructure.

Reviewer 2:

The reviewer mentioned they had no comment but noted the approach and next steps should be re-evaluated to address stated project barriers.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said the funding is sufficient for the development and field demonstration of multiple 150 kW DCFC units in use with a small fleet of BEVs.

Presentation Number: ELT283
Presentation Title: A Solid State Technology Enabled Compact, Modular Design to Reduce DC Fast Charging Cost and Footprint
Principal Investigator: Vijay Bhavaraju (Eaton)

Presenter

Vijay Bhavaraju, Eaton

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 67% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 33% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

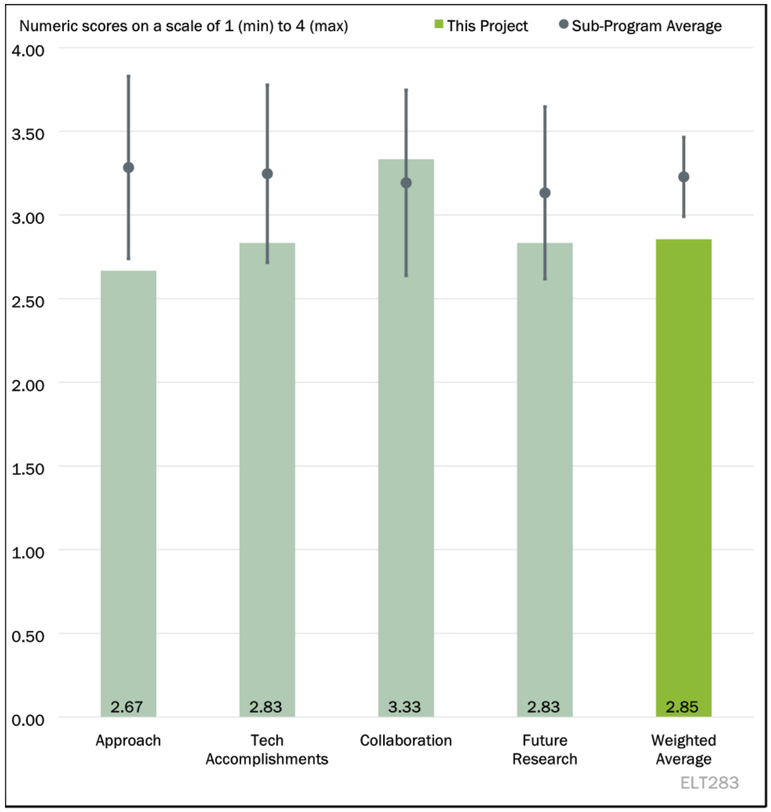

Figure 2-26 - Presentation Number: ELT283 Presentation Title: A Solid State Technology Enabled Compact, Modular Design to Reduce DC Fast Charging Cost and Footprint Principal Investigator: Vijay Bhavaraju (Eaton)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer remarked this appears to be an excellent project addressing the needs of early EV adopters and infrastructure cost.

Reviewer 2:

The reviewer commented the project addresses details for reducing the footprint size of medium voltage connected, megawatt charging systems. No clear details were provided on how the project deliverables will decrease costs or ensure interoperability with megawatt charging capable EVs.

Reviewer 3:

The reviewer commented that while this is a technically deep and comprehensive project, the presentation does not include information on the barriers of the footprint, and the information on cost-reduction is inadequate. The presentation needs a short introduction on the baseline technology and how this project is going to improve the situation. There was not discussion of footprint reduction or key problems solved with respect to interoperability. Finally, the reviewer added that their “fair” score could be considerably improved with added information.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer said the material seems to clearly articulate all the achievements and well documents project progress.

Reviewer 2:

The reviewer said the overall progress in design and construction appears good, but the impact on the barriers of size, cost, etc. is not well covered. The recording contained appropriate information on some hindrances to progress that was helpful and understood.

Reviewer 3:

The reviewer noted the project has accomplished several design and modeling tasks as well as initiated the underserved community requirements process. The project results do not include any cost estimates for the completed designs or comparisons to the cost for a comparable state-of-the-art medium voltage-connected MW charger. The project does not include any results or accomplishments to ensure interoperability with MW charging capable vehicles.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer commented there seems to be a healthy share of responsibilities amongst project partners.

Reviewer 2:

The reviewer said the tasks by the contributing team members are tabulated and adequately described. The recorded presentation was beneficial in this category. It would be useful to see the approximate funding to each partner. The team’s effort to understand and support benefits in underserved/impacted communities is articulated clearly, and commendable. The reviewer said the workshop mentioned seems like a good idea.

Reviewer 3:

The reviewer remarked the project includes project partners with modeling expertise and underserved community outreach experience. Consider adding project partners for improved capabilities to successfully test and demonstrate the medium voltage connected megawatt charging infrastructure.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer commented the remaining challenges are well articulated.

Reviewer 2:

The reviewer said the requirements and challenges to complete the device and install it are presented clearly. The future work should include, however, an analysis of the impact on the barriers of cost and footprint, etc.

Reviewer 3:

The reviewer noted the project’s proposed future research includes design and modeling of advanced power electronics topologies and controls including DER. Consider testing and demonstrating the megawatt charging system in the current project to gain lessons learned, prior to further modeling and design of other advanced topologies.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer noted the project's focuses on electrification/mobility systems.

Reviewer 2:

The reviewer remarked improvements in charging equipment and infrastructure are certainly relevant to VTO's overall mission to enable progress toward low-carbon mobility. Cost reduction and minimizing intrusion on communities are good objectives.

Reviewer 3:

The reviewer commented reduced costs for medium voltage connected megawatt charging systems directly supports the objectives to advance electrified transportation charging infrastructure system integration.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said the project seems to be adequately funded.

Reviewer 2:

The reviewer suggested showing distribution of resources across team members.

Reviewer 3:

The reviewer said that for this 3-year project, the project claims 57% completed after 13 months (May 2022 to June 2023). This indicates the project is anticipated to be underbudget by the completion of the project milestones.

Presentation Number: ELT284
Presentation Title: Ultra-low Cost, All-SiC Modular Power Converters for DC Fast Charging Equipment Connected Directly to Medium Voltage Distribution System
Principal Investigator: Srdjan Lukic (North Carolina State University)

Presenter

Srdjan Lukic, North Carolina State University

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

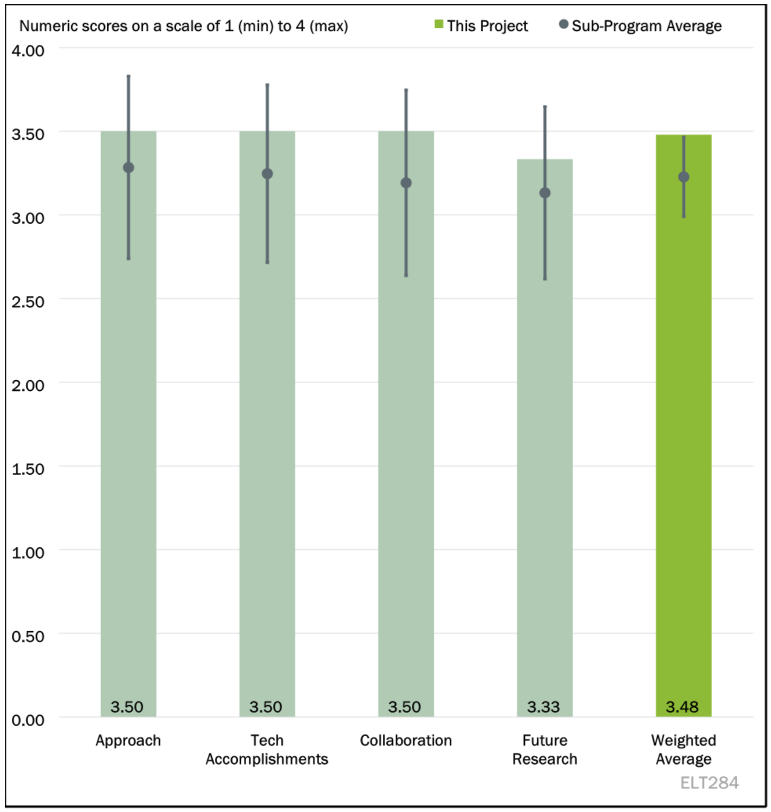

Figure 2-27 - Presentation Number: ELT284 Presentation Title: Ultra-low Cost, All-SiC Modular Power Converters for DC Fast Charging Equipment Connected Directly to Medium Voltage Distribution System Principal Investigator: Srdjan Lukic (North Carolina State University)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer said the project is well designed to include technical as well as financial objectives. While Multi-port DAB is complex to control, the cost of the system should be reduced with an overall decrease in hardware components. When DAB circulating currents were discovered to be causing a loss of efficiency, the team set out to redesign the magnetics to get that efficiency back. The reviewer stated being happy to see that this project includes as a part of its scope a cost of ownership analysis.

Reviewer 2:

The approach of this project is tailored to reduce cost of XFC by resorting to the single-stage power conversion, resulting in expected 50% cost reduction compared to the baseline XFC engineered through project ELT238. Use of the SiC devices is targeted to lower the footprint of the magnetic circuit used in an XFC system, which matches with engineering practices, presently prevalent in the power electronic field. The reviewer noted the cost reduction realization will be achieved by minimizing the cost of protection mechanism used with the underlined XFC system.

Reviewer 3:

The reviewer noted the project has very strong, clear objectives and deliverables covering technical, cost, and business aspects of SST technology development and commercialization. Regarding objectives, this reviewer reported reducing the cost of SST-based EVSE by at least 50% compared to baseline system; improving reliability; and identifying best technology insertion points by analyzing the TCO of SST-based EVSE. Concerning deliverables, the reviewer noted that all SiC-based EVSEs are operational in the field and highlighted TCO analysis.

The reviewer said SST-based systems will have higher efficiency (SST expected efficiency greater than 97%) and smaller footprint compared to conventional baseline systems. The overall cost reduction approach is excellent. There is a very heavy emphasis upon cost reduction through analysis, establishing cost of ownership targets, and initial prototyping very early in the project (Fiscal Year 2023). The reviewer said the project incorporates a number of innovative cost reduction strategies including: (1) design for manufacturing / utilizing same device / cooling construction; minimizing the cost of DC protection and; (2) minimizing the cost of DC nodes through galvanic isolation from the SST. The total cost of TCO methodology is comprehensive including not only upfront equipment costs, but also maintenance and operations costs. Model development scenarios are being explored/examined including regional variances and recommendations for best use case scenarios. Furthermore, it is good to see extensive industry interviews (manufacturers, installers, owner/operators, and fleet managers) being included in the project. The project has incorporated risk mitigation strategies of which Danfoss has been instrumental. This includes a technology transfer plan with multiple pathways to market and standards testing to be conducted as part of testing in budget period 3.

Finally, the project also incorporates proactive workforce development.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer said the project has demonstrated very strong technical progress in the first year, as well as emphasis upon cost reduction and market transition strategies. A comprehensive topology tradeoff was conducted prior to settling upon the pseudo flying capacitor approach which is relatively low risk. Technical progress includes: systems specifications defined and topology selected; initial transformer prototyping complete; initial simulations meeting performance and efficiency targets; and the project is on track to quantify the value proposition and determine the best insertion points for technology and to quantify the benefit over the state of the art.

Reviewer 2:

The reviewer said it is early in the project, but accomplishments have been good as compared to the plan. The project fell behind at the beginning because the needed cost analysis and cost of ownership targets were late to engage but it looks like it is running to plan now (with a small, no-cost extension).

Reviewer 3:

The reviewer said the timeline of the project is targeted for high level activities starting from development followed by optimization which leads to system integration and development in last budget period during 2025–2026 timeframe. Each of these high-level tasks have many relevant sub-tasks outlined in the project report. The reviewer cited system specifications are developed and included in the project report. Adopted system topology illustrated in the project report. Outcome of topology takeoff study summarized in a table and included in the project report. Pseudo flying capacitor-based topology selected for the XFC power stage. Multiport DAB and its benefits described. Overall efficiency of the proposed XFC assessed and efficiency plot as function of power included in the project report. Homemade transformer for SST fabricated and picture included in the project report. Methodology outlined for the TCO and tabulated data included in the project report. Cost reduction strategy resorts to elimination of switch gear and outlined and illustrated in the project report. The project has a workforce development plan, which is desirable and appropriate as industry needs technical experts who could become instrumental in EV adoption. The technology transfer plan outlined in the project report including PI aspirations to launch a start-up company.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer noted a good team of partners and contributions, and partners appear to play to each of their strengths. Great to see Workforce Development as a part of this plan. The reviewer hopes it pays dividends many times over.

Reviewer 2:

The reviewer remarked strong collaboration exists in execution of project activities and multiple entities are involved in the North Carolina State University-led project and the project team includes many industries.

Reviewer 3:

The reviewer commented the project team is lean and appears to be well rounded and appropriate. The team covers all relevant aspects including R&D, cost analysis, demonstration, and business/commercialization. No readily apparent gaps are noted in the team structure.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer said well-planned with tasks and timing communicated. When executed to that plan the project will demonstrate the technologies and cost effectiveness of those technologies.

Reviewer 2:

The reviewer remarked remaining challenges and barriers have been comprehensively identified, including those that are technical/design, cost/business, and project related in nature. Out-year tasks (including team roles and responsibilities) are presented which seem very appropriate. It is important to continue to address market/commercialization barriers (such as codes and standards, and regulatory/policy) regarding SST-based systems and whether utilities/PUCs will allow their incorporation. The PI has indicated that more demonstration projects will help reduce barriers and improve customer acceptance. It may be beneficial to continue to brainstorm further solution pathways regarding market/commercialization barriers.

Reviewer 3:

The reviewer commented the project report outlines future research, which is relevant and appropriate. Multiport DAB reduces cost, which is good. However, risks of DC current offset and possibility of magnetic circuit saturation need to be included as one of the tasks in the project activities. Otherwise, there is a possibility that this important aspect may remain unexplored, resulting in the possibility of an outcome that may be far from commercialization.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer pointed out that medium and HD EVs will require very high-power charging (up to and exceeding 1 MW). To provide the necessary power at a reasonable cost, direct connection to medium voltage

(MV) will likely be needed. New approaches to increase access, ease installation, and drive down infrastructure costs will be needed. The development and successful commercialization of SSTs will be instrumental to this effort.

Reviewer 2:

The reviewer noted how a cost-reduced (50%), modular, medium-voltage grid connected, fast charging system, if successful, has the potential to boost the uptake of EV charging availability throughout the United States.

Reviewer 3:

The reviewer said this project is relevant to VTO's electrification sub-program and will accelerate adoption of EVs by availability of XFC to HD and light-duty vehicles, and utilities will feel comfortable in allowing XFC interface with MV grid.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said resources are sufficient and having a partner like Danfoss, which brings commercial considerations to technical solutions, is probably helping in timely and cost-effective decision making on this project.

Reviewer 2:

The reviewer commented the project has necessary resources and research funds.

Reviewer 3:

The reviewer said the project appears sufficiently funded and exhibits 27% cost share, which is good.

Presentation Number: ELT285
Presentation Title: Development and Demonstration of Zero-Emission Technologies for Commercial Fleets (Supertruck 3)
Principal Investigator: Maarten Meijer (PACCAR)

Presenter

Maarten Meijer, PACCAR

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 25% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

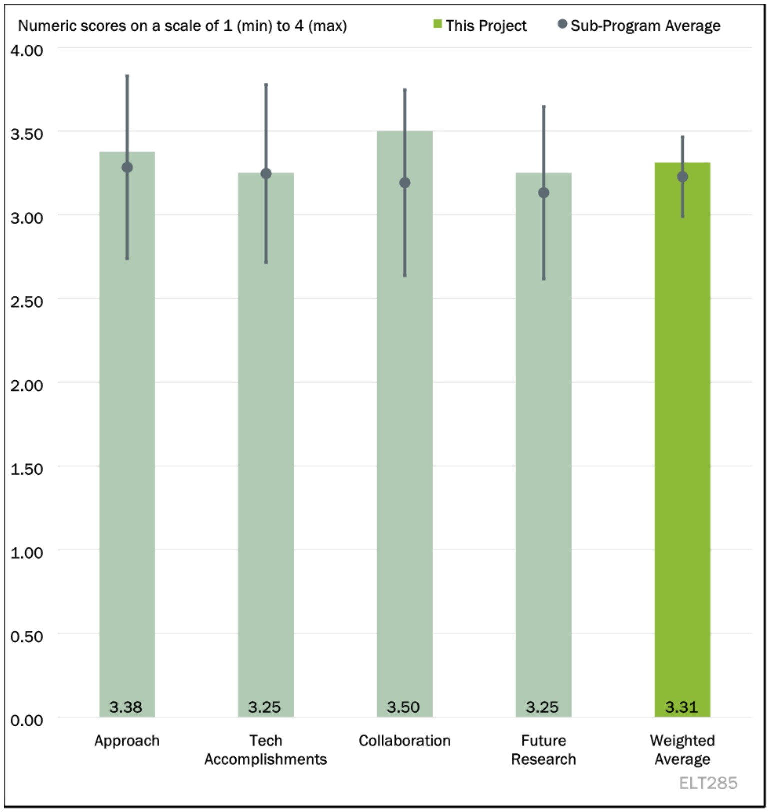

Figure 2-28 - Presentation Number: ELT285 Presentation Title: Development and Demonstration of Zero-Emission Technologies for Commercial Fleets (Supertruck 3) Principal Investigator: Maarten Meijer (PACCAR)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer remarked PACCAR has a project plan that is well considered and will push our current experience of technology.

Reviewer 2:

The reviewer said the barriers were well explained with technology areas being well explained and categorized (Vehicle/Powertrain/Infrastructure). Given this being the early phase of this project and complexity of a zero-emissions transport system (changing from internal combustion engine (ICE) to BEV in commercial fleets), as well as the carbon emissions and cost of ownership targets, development and demonstration, and finally breadth of team involved (fleet partners, research, charging expertise needed, etc.), the project appears well defined. It was helpful hearing brief explanation of the key technologies, by category. The timeline seems well planned given the scope of work.

Reviewer 3:

The reviewer said good content, timeline, and plan covering most of the deliverables. The reviewer would have liked to see a cost comparison to a diesel baseline, not just to the high-cost gen 1 BEV. Secondly, the reviewer would like to see an energy tracking tool, how does the project move forward the kilowatt-hour/mile needed to have acceptable TCO? Finally, the speaker mentioned that energy cost is included in the 40% TCO reduction, what are the details for how the charging infrastructure and energy costs are included?

Reviewer 4:

The reviewer said this is a comprehensive program to cover all aspects of BEV deployment in Class 8 HD trucks. It is important for the freight industry to continue to have multiple options with respect to OEMs and their different approaches to providing products and distribution for this sector. The approach is methodical and well planned with incremental development and validation. The reviewer did have a concern that the 30%–40% TCO reduction is against a somewhat fluid baseline. There is not much Gen1 operating data and long-term uptime, or maintenance costs will not be available. From a customer's perspective, the reviewer mentioned venturing a guess that they would much rather understand the TCO comparison to their existing well-known diesel fleet. Finally, the program has not provided many quantifiable targets with respect to performance or duty cycle. The reviewer stated that they would like to see more details in this regard.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer remarked very early in the project, but a good plan exists.

Reviewer 2:

The reviewer said that with BEV trucks already having been put on the road, with needed equipment and data logging and driver training already well underway, technical progress is proceeding well for this period. Understanding potential challenges of supply chains, having the purchase orders for microgrid infrastructure submitted and 20% of chargers (2 out of 10) installed shows progress. Having changed the fast-charging scope due to unforeseen circumstances with the utility supplier is understandable; moving to an OEM facility for testing is a laudable alternative.

Reviewer 3:

The reviewer said this is very early in a large project. The more difficult development and hardware delivery milestones are yet to come but Gen 1 trucks and some chargers have been deployed, which is a good and necessary start. The team should address how the removal of the fast chargers from the Gen 1 scope will affect the program's ability to establish baseline performance and uptime.

Reviewer 4:

The reviewer commented PACCAR has included most of the latest technology in their plan, and also has an excellent idea to perform the FCEV study. One huge miss is the team's baseline for the TCO calculation. First, any project should only have one baseline—PACCAR has two. In addition, when questioned about this during the review, the PI stated that this baseline was undefined.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer said very good beginning of partner activity.

Reviewer 2:

The reviewer commented of course, it is still early days with this project. However, PACCAR appears to have an excellent plan for collaboration with several good partners.

Reviewer 3:

The reviewer stated at this early stage, with the work just getting started, the scoring is mainly based on the fact that collaborators for the project and its major sub-systems are on board.

Reviewer 4:

The reviewer pointed out the project team participants, particularly the fleet partners for deployment/data collection, have strong reputations for scrutinizing operational viability of new technologies as well as adopting those that prove viable. The progress shown to date is illustrative of strong collaboration. Since there was a challenge of the utility supplier reducing incentives, resulting in the decision to move megawatt charge testing to an OEM facility, it would be helpful to include in the future project outcome/report a brief summary of the facts leading to this change, as an instructional/informational tale for others to learn from.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer commented the proposed future research is broadly described but appears to be appropriate for the project.

Reviewer 2:

The reviewer said excellent, the most difficult aspects of HD BEVs are covered including battery development, e axle, sub systems, and charging.

Reviewer 3:

The reviewer said all the future work proposed is good. Having said that, PACCAR should have included more real-world fleet testing—this is one of the primary purposes of the SuperTruck program.

Reviewer 4:

The reviewer considered the scope of the project's Gen 2 and Gen 3 deployments and track testing plans highly relevant to the national research needs in this area, and they are well defined in the overview. Experience from these deployments (and testing/validation) are essential to the overall carbon reduction approach for the transportation sector. Gen 3 efforts planned to build test beds for proving out technology maturity, especially in long haul (HD) operations, where BEV implementation is particularly challenging, is a needed outcome and helpful target. In addition to the quantitative data collection in the fleet deployments, will there be some qualitative information collected from the fleets relative to successes and challenges? Driver acceptance? Experience with charging installation? Scalability for the fleets?

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer said the project is highly relevant to DOE goals and includes work in most VTO sub program areas.

Reviewer 2:

The reviewer said zero emissions medium- and HD trucks must be considered as part of the VTO's objectives of reducing the transportation sectors' carbon emissions. This project aims squarely at testing/deploying zero emissions technology, with the anticipated outcome, after on-road and test center results, helping to prove feasibility in real world environment.

Reviewer 3:

The reviewer said broadly speaking, the project supports the VTO's goal of developing affordable, efficient, and clean transportation options. The reviewer's question, more for the VTO than the project team, is whether this SuperTruck is "Super" enough? Is the project truly accelerating development of the next generation of technologies or is it riding a wave that is there to be ridden?

Reviewer 4:

The reviewer remarked that the PACCAR SuperTruck 3 project is extremely relevant. The reviewer reiterated a huge miss with the team's TCO baseline approach.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said resources appear to be sufficient to complete the project in a timely fashion.

Reviewer 2:

The reviewer pointed out that trucks are expensive. Test trucks, effectively prototypes, are more expensive, and while more trucks (for more test data miles) could be desired, the reviewer considers the resources planned in this project to be sufficient. The phased approach (Gen 1, 2, and 3 trucks) incrementally builds on prior learning.

Reviewer 3:

The reviewer remarked it is difficult to ascertain at this early stage of the project.

Reviewer 4:

The reviewer was unclear why PACCAR received almost twice the funding of Volvo. The projects appear to be similar in scope.

Presentation Number: ELT286
Presentation Title: A Zero Emission Freight Future (SuperTruck 3)
Principal Investigator: Eric Bond (Volvo Trucks)

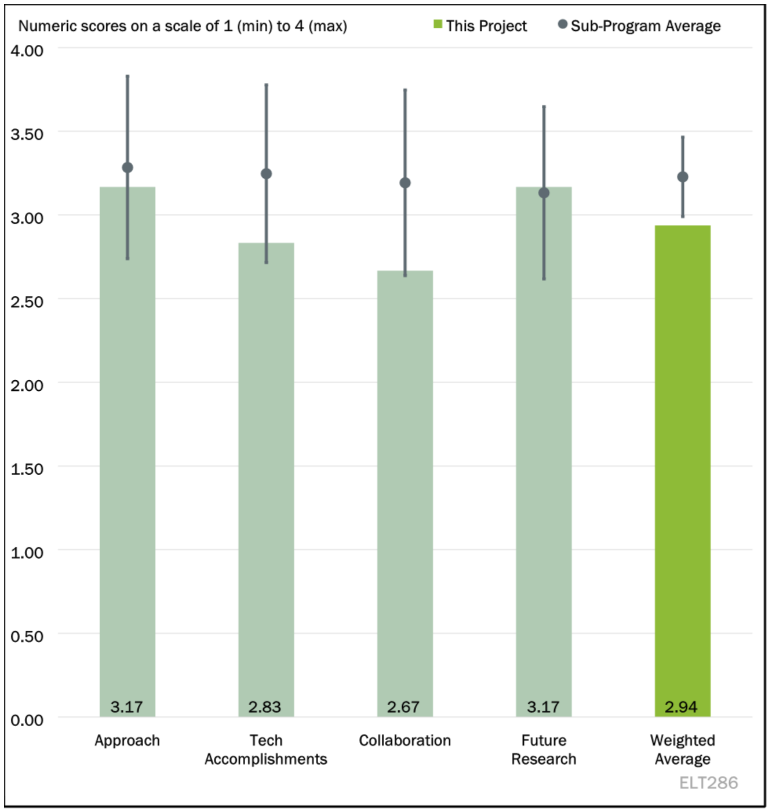

Figure 2-29 - Presentation Number: ELT286 Presentation Title: A Zero Emission Freight Future (SuperTruck 3) Principal Investigator: Eric Bond (Volvo Trucks)

Presenter

Eric Bond, Volvo Trucks

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 67% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 33% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer said Volvo's approach to the SuperTruck 3 program is really good. Building on the success of SuperTruck 1 and 2 is also very good. The approach would have been even better if the team had considered a hydrogen concept—at least a study.

Reviewer 2:

The reviewer cited technical barriers—it is commendable to start with modeling/analysis to test out the targets preliminarily. Also, this work builds on SuperTruck 1 and 2, which bolsters this project design. Moving from the ICE baseline to BEV drivetrain sets a high bar for HD long haul, with battery weight and size (volume) a challenge. Also, moving from 4x2 to 6x4, longer wheelbase, higher gross combination weight (per the design plan) brings the resulting vehicle on par with the mainstay highway (long-haul) tractor in operation today.

Reviewer 3:

The reviewer said the presentation severely lacks much of the needed technical details to do a fair assessment.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer said that the project is moving along. There are no details beyond, "we are still working on it." To be fair, the project started not even a year ago.

Reviewer 2:

The reviewer commented technical progress has been made. The ESS investigation is ongoing (battery, cell types, energy density/capacity, state of charge, performance and form factor) and all are included in the project. The reviewer noted the team is redesigning hood and chassis to optimize for BEV, as well as trailer design/spec changes on account of new tire sizes (new tire development by partner Michelin).

Reviewer 3:

The reviewer remarked that the technology studies performed to date are really good. However, the discussion about the compromise for tire wear versus tire rolling resistance is misleading on Slide 12. A compromise means that one of the characteristics goes down while the other characteristic goes up. This comment needs clarification. An Assumptions slide would have added more detail to the presentation.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer said Volvo has a good list of partners for collaboration. However, the team is already one full year into the project and do not yet have a fleet partner.

Reviewer 2:

The reviewer commented the initial collaboration seems well in line with expectations of DOE research funding, with anticipated work among OEM, suppliers, fleet partner (to be determined), academia and national laboratories contributing. It is very important to include in the future final report the perspectives from a fleet partner (who could be a future user of the BEV truck) on practical implementation on the road—TCO approximations, day to day operation benefits/drawbacks (charging, operating, tire management, ride height, driving, reliability of the tractor/trailer systems, etc.).

Reviewer 3:

The reviewer noted that collaborators are mentioned but it is hard to understand who is doing what between Rensselaer Polytechnic Institute and ORNL.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer said the team appears to know what to do next.

Reviewer 2:

The reviewer said future research is clearly defined, with proving out the simulation/analysis work of the early phase into the design and vehicle integration looking ahead (and the vehicle demonstration). The reviewer appeals for the project team to consider engaging a potential fleet customer(s), local power utility representation, and municipality (building code officials) representation to witness/be aware of and provide feedback with their perspectives/observations—either qualitative or quantitative in nature—on the vehicle demo and/or megawatt charging demonstrations, if resources allow.

Reviewer 3:

The reviewer pointed out that one of the primary purposes of the SuperTruck program is to get real-world experience. Working close with a fleet and gaining additional real-world experience should have been included in the future research.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer said the relevance of the project is clearly in line with VTO priorities. This BEV development addresses analysis, batteries, electrification, energy efficient mobility systems, and materials all in one vehicle product (as well as the supporting analysis and design development). Long haul freight a disproportionally large fraction of energy for transport, so SuperTruck 3 aims directly at the DOE goals.

Reviewer 2:

The reviewer said this project is extremely relevant. Volvo talks about improving the TCO, but does not identify a baseline for this improvement—this should be added for the next AMR.

Reviewer 3:

The reviewer said electrification.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer remarked with funding expected to produce design and vehicle integration and demonstration of a BEV freight truck (with 400-mi range and megawatt charging system), the motor carrier movers of freight (and consumers of fuel) need this R&D and demonstration to advance acceptance and prove viability of BEVs to help meet our carbon reduction goals.

Reviewer 2:

The reviewer commented resources for this project seem to be appropriate.

Reviewer 3:

The reviewer said it is a good ratio for DOE, but still it is a lot of money, which could be used more efficiently within DOE for a smaller proof of concept.

Presentation Number: ELT287
Presentation Title: Cummins High Power Density Inverter
Principal Investigator: Santhosh Krishnamoorthi (Cummins)

Presenter

Santhosh Krishnamoorthi, Cummins

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

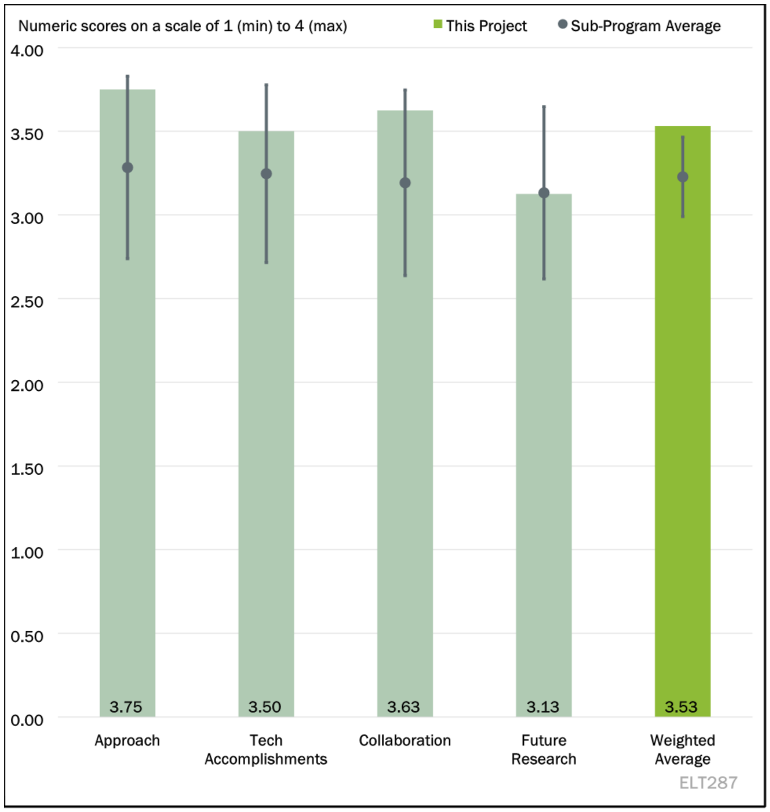

Figure 2-30 - Presentation Number: ELT287 Presentation Title: Cummins High Power Density Inverter Principal Investigator: Santhosh Krishnamoorthi (Cummins)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer said the team is developing a high-power-density inverter. The team has considered all aspects of the design—not just the power stage, but also control, sensors, capacitors, and bus bars.

Reviewer 2:

The reviewer said the project team has aligned technology to be developed to Cummins' needs while attempting to meet DOE 2025 targets for power density, cost, and reliability. The 100 kW/L target is for DC bus operation greater than 650V, therefore, selection of a near 1000V DC bus will allow a much easier way to meet 100 kW/L power-density target. It is an appropriate engineering process and the project team's approach is setting goals and then thinking through to outline various goals including cost, power-density, and durability. Use of CeraLink capacitor in inverter packaging will pose a roadblock in meeting the cost target.

Reviewer 3:

The reviewer remarked the approach to address the technical barriers is on track. The reviewer would like to see the physical testing plan and related DVP&R and under what conditions it will be performed.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer said the team has completed much of the design, at least in pieces. The team has made some important design decisions, such as the topology, though some are fairly obvious choices. With few exceptions, though, no experimental validation is available at this time. For example, the gate drive power supply has been designed and components have been ordered, but the design has not been tested yet. Still, preliminary indications are positive. There is also good progress on the reliability analysis.

Reviewer 2:

The reviewer noted the standard six switch inverter topology for 300 kW peak power was selected by analytical processes, it is simple and appropriate and as per engineering practice by automotive companies. Doable side power module design concept developed in collaboration with Virginia Tech. Gate drive supply design concept developed and optimized. However, it seems like power supply transformer could occupy undesirable level of real state inside an inverter box. A commercially available current sensor selected bus bar design was completed, however stray inductance is over 15nH, this needs to be lowered, particularly form inverter over current protection set point standpoint and safe turn-off under excessively high current. The team developed a capacitor packaging concept, and a project collaborator is evaluation EMI suppression by packaging. Manifold based heatsink design concept developed. Control board development and inverter control software development works are under progress. Inverter reliability is assessed for applications such as pickup and delivery, school bus, etc.

Reviewer 3:

The reviewer said progress is on track, but the reviewer recommended having a detailed DVP&R to consider worst-case test conditions.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer remarked the team is thoughtfully composed with an appropriate division of tasks in alignment with team member expertise. There is good evidence that the team members are working together towards common goals.

Reviewer 2:

The reviewer said strong collaboration exists in execution of project activities as the project team led by Cummins has two national laboratories and Virginia Tech as collaborators.

Reviewer 3:

The reviewer said collaboration is on track.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer said the team has a good plan for testing subsystems and integrating them. The team has identified areas where changes are expected, such as the EMI filter, as well as the challenges that they need to overcome.

Reviewer 2:

The reviewer remarked the project team has outlined future research for Fiscal Year 2023 and Fiscal Year 2024. This reviewer suggested developing a realistic commercialization pathway including a supply chain of enabling components for the proposed 300 kW peak power inverter.

Reviewer 3:

The reviewer commented an impact analysis of reliability achieved from target design based on volume of greater than 3 liters compared to the DOE target design of greater than 1 liter would be more valuable.

Reviewer 4:

The reviewer said the project needs to test on a dynamometer and vehicles to confirm objectives are met.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer said the team has set appropriate targets that are aligned with the power and power density goals of the VTO program.

Reviewer 2:

The reviewer agreed this project is relevant to the VTO subprogram in the electrification area, and the project is trying to meet DOE’s 2025 targets for cost, power-density, and durability of the traction inverter.

Reviewer 3:

The reviewer said real-world applications and growth in electrification, focus on performance and cost objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented effort, progress, and plans are commensurate with the resource allocation.

Reviewer 2:

The reviewer said the project has necessary resources and research funds.

Reviewer 3:

The reviewer said resources are on track.

Presentation Number: ELT288
Presentation Title: Scalable Ultra Power-Dense Extended Range (SUPER) Inverter
Principal Investigator: Harsha Nanjundaswamy (Borg Warner)

Presenter

Harsha Nanjundaswamy, Borg Warner

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

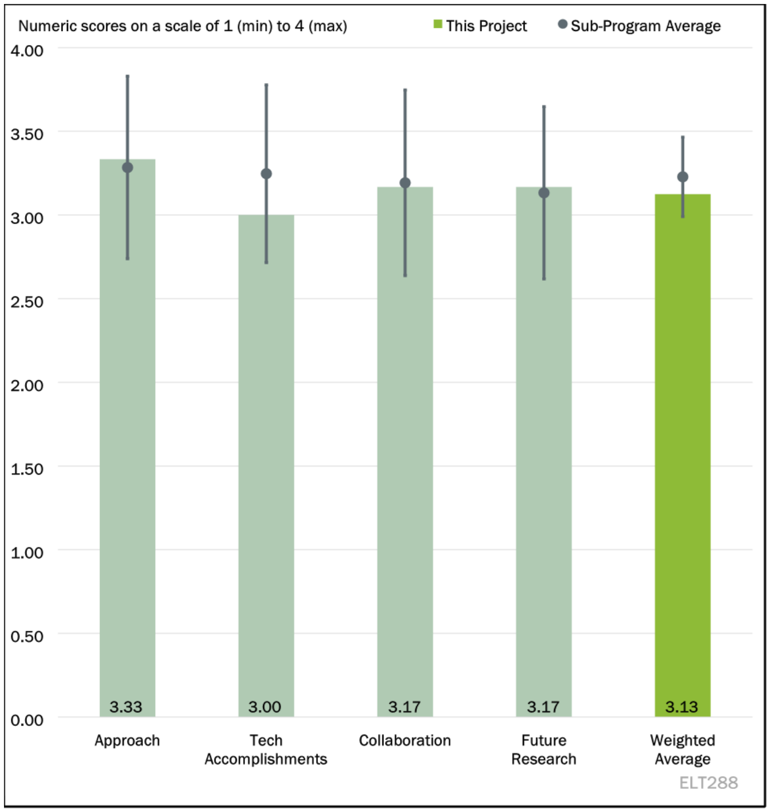

Figure 2-31 - Presentation Number: ELT288 Presentation Title: Scalable Ultra Power-Dense Extended Range (SUPER) Inverter Principal Investigator: Harsha Nanjundaswamy (Borg Warner)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer said this project integrates a new device package concept with a variety of other supporting elements, such as a safety application-specific integrated circuit (ASIC) and new capacitors.

Reviewer 2:

The reviewer commented the presenter repeatedly stressed the fact that commercialization, high speed, and high-volume manufacturing were always kept in focus. This is very good, because this ensures that the project has a much better chance of seeing the light of day. The only slight concern is that, with the hyper-focus on commercialization, are technologies and designs that may be potentially game changing being ignored? If the purpose of this project is to continue development of internal projects that were already in progress, then the intent of the funding is not quite satisfied.

Reviewer 3:

The reviewer expected to see a detailed timeline and test cadence based on DVP&R.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer said this project is expected to yield a real-world production application with key performance and cost metrics.

Reviewer 2:

The reviewer said the team has made excellent progress on design tasks, including a new device package, a new cold plate, and new capacitors. The team is evaluating thermal interface material (TIM) options. The electrical architecture incorporates an ASIC that was already in development, providing the first demonstration. The entire design is oriented towards high-volume manufacturing. At this time, very limited experimental results are available, however, with an emphasis on simulations.

Reviewer 3:

The reviewer noted that all the required design/concept reviews required for budget period 1 appear to be on track. The next budget periods are the meat of the project, and it will be interesting to see the outcome over the next two budget periods. The reviewer said targets for reliability need to be clarified. Fifteen years/300,000 miles is a good target to have, but without a clear definition of the mission profile, this does not carry much meaning. For instance, using 300,000 miles of Federal Test Procedure city and highway cycles as a reliability target is not necessarily appropriate, because there are far more severe real world driving events that take place routinely. It is also not clear what the target for efficiency is, and over what drive cycle the efficiency would be measured.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer noted there is a very good cross section of academia, national laboratories, and suppliers involved in the project.

Reviewer 2:

The reviewer said the work up to this point is well-coordinated with an appropriate division of tasks. However, future engagement with Virginia Tech Center for Power Electronics Systems is unclear.

Reviewer 3:

The reviewer suggested having a customer focused application in mind as the project continues.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer said the project seems to be on track for full validation. As previously noted, the role of Virginia Tech in future research is unclear.

Reviewer 2:

The reviewer remarked so far, during the budget period one, mainly the down-selection process appears to have been completed with no actual hardware being built. The next two budget periods will cover all of the prototype building and validation. However, the issues that raised in the response to Question 4 need to be addressed.

Reviewer 3:

The reviewer said base the testing and validation on a detailed DVP&R.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer said the project directly addresses inverter power and power density with an innovative packaging approach and other components. Importantly, it also addresses cost directly.

Reviewer 2:

The reviewer pointed out that space is always a premium when designing electric drive units, and an increased power density inverter definitely helps in easing the packaging issues that are faced.

Reviewer 3:

The reviewer noted efficiency and cost objectives are critical to meet.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said the project is appropriately scaled to the available resources.

Reviewer 2:

The reviewer remarked resources are sufficient.

Reviewer 3:

The reviewer said resources are on track.

Presentation Number: ELT290
Presentation Title: Behind-the-Meter-Storage
Principal Investigator: Matthew Keyser (National Renewable Energy Laboratory)

Presenter

Matthew Keyser, National Renewable Energy Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

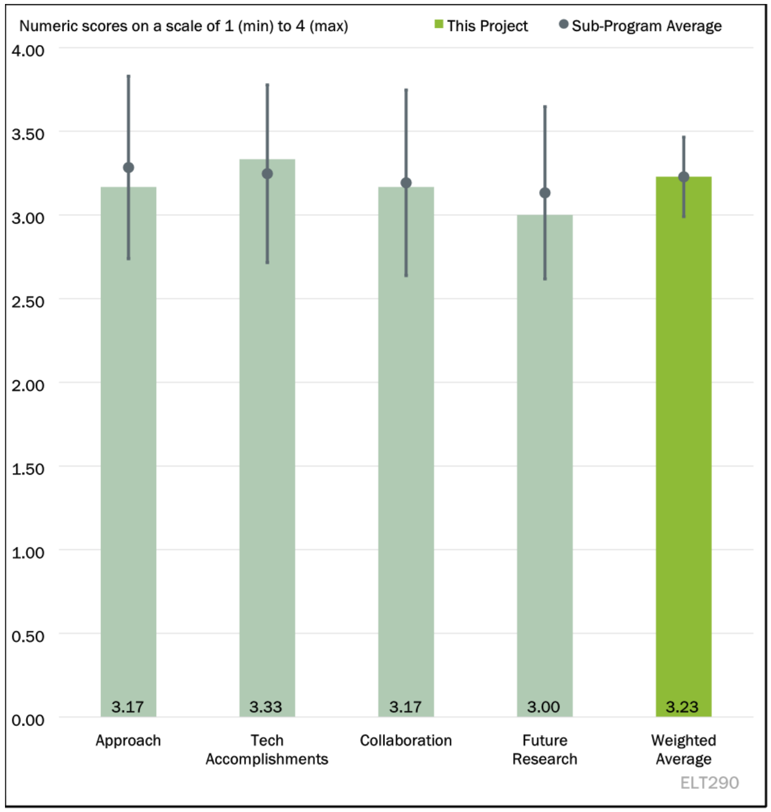

Figure 2-32 - Presentation Number: ELT290 Presentation Title: Behind-the-Meter-Storage Principal Investigator: Matthew Keyser (National Renewable Energy Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer noted the critical barrier for this project is the buffer battery ESS and the project team addressed this by focusing most of the research on battery chemistry, cycle life, and battery safety research. The project has a clear timeline, specific milestones, and well-designed testing plans. When the original project plan was prepared in 2018, it correctly reflected the ESS industry at that time: most ESS still used cells designed for EVs and nickel manganese cobalt (NMC) was the major ESS battery chemistry, but the ESS battery technology and market has changed dramatically. Since 2021, lithium iron phosphate (LFP) has become the dominant chemistry due to cost and safety reasons and NMC is losing most of its ESS market share. And the lithium titanium oxide (LTO) battery has only less than 1% of the lithium-ion battery market and is not commonly used for ESS. In the future, LTO could potentially take some niche ESS or commercial electric vehicle market that require very long cycle life, but this will not be certain due to its low energy density and higher cost. Thus, if allowed, maybe the project plan could be modified with time accordingly.

Reviewer 2:

The reviewer advised the first step in this project should have been to make an attempt to determine the number of charging ports that are typically needed in a building as a function of square footage of occupancy or number of occupants in the building under certain assumptions, such as, a ratio of EVs per occupants and a percentage of occupants with EVs which would need to be charged during the time they are occupying the building. The assumption of fast charging (e.g., for 200-mile range in 10 mins.) rather than slow (or overnight charging) is reasonable because the building is assumed not to be for residential purposes but for office, business, or other commercial use. The reviewer advised the second step to make things simple is to start with locating the battery ESS outside the building and once that is optimized, work towards putting it inside the building. Third, the reviewer questions whether battery development (including strings of batteries) should be a part of this project. Battery development should be left to the scientists/engineers who specialize in that particular area, and this project should take the most optimum stationary battery that has been developed as the starting point for this project. Fourth, the reviewer likes the idea of looking at five different topologies, active vs. passive state of charge balancing, utilization of isolated dual-active bridge converters, etc.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer said good progress has been made in areas including high nickel NMC, lithium-ion manganese oxide (LMO)/LTO cell cycle life analysis, small multi-cell module safety testing, different types of building load profiles, ESS/photovoltaic design across climates and utility rate schedules, etc.

Reviewer 2:

The reviewer was not clear when the PI knew that cobalt is fairly limited in availability. If it was known at the beginning of the project, then the project should have started off with LMO/LTO cells instead of either NMC622/graphite or NM/LTO cells. That would have saved a lot of time, perhaps 2–3 years could have been saved.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer said the role and responsibility are very clear for each of the of 5 national laboratories involved. Collaboration or close communication between national laboratories and industry like more frequent U.S. DRIVE update meetings could help adjust the project plan based on the changing ESS market and latest commercial ESS technologies.

Reviewer 2:

The reviewer said the collaboration team does not include building architects and engineers who have the expertise in designing fire walls and fire suppression systems as well as mitigating risk. There should have been a due diligence attempt to search for building architect/engineers who have incorporated battery ESSs in buildings already. For example, there may be sufficient designs for firewalls and fire suppression systems that could contain or control thermal runaways totally within the firewalls without requiring research and development on thermal control and management of batteries at the cell level, module level, pack level and rack level.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer said most future work listed on Slide 23 on battery management system (BMS) look good. The reviewer suggested placing priority on the work related to ESS safety like sensing technology, BMS safety features, etc. One recommendation for future work on battery development: Plenty of work has been done on LTO and NMC/Gr batteries in this project. Suggest future work focus more on LFP, especially safety design of large commercial LFP cells, modules, and packs. For this project, the reviewer suggested balance the total effort spent on battery development and focus more on the safe use of ESS as part of the behind the meter (BTM) system: solar, thermal storage, smart building, EVSE, etc.

Reviewer 2:

The reviewer indicated that the project goals, objectives, and targets are not well-defined and specific; rather they are very nebulous and murky. The PI should have articulated specific goals, objectives, and targets. Just telling reviewers that the project needs to address the barriers of cost, performance, and safety is insufficient. In what particular area or aspect is the cost too high? What performance needs to be improved? What safety needs to be improved (e.g., are all thermal runaways to be eliminated)?

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer said this project is quite relevant to many VTO subprograms such as XFC, Electrification, Mobility, etc.

Reviewer 2:

The reviewer remarked the project is relevant, but premature. The reviewer really does not think there is enough demand (i.e., demand has not reached the tipping point) for EVs to start incorporating charging stations as part of building infrastructure.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said enough resources are provided from the world-leading national laboratories.

Reviewer 2:

The reviewer thought $2.4 million is way more than needed for this project.

Presentation Number: ELT291
Presentation Title: Enabling Extreme Fast Charging with Energy Storage
Principal Investigator: Jonathan Kimball (Missouri University S&T)

Presenter

Jonathan Kimball, Missouri University S&T

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

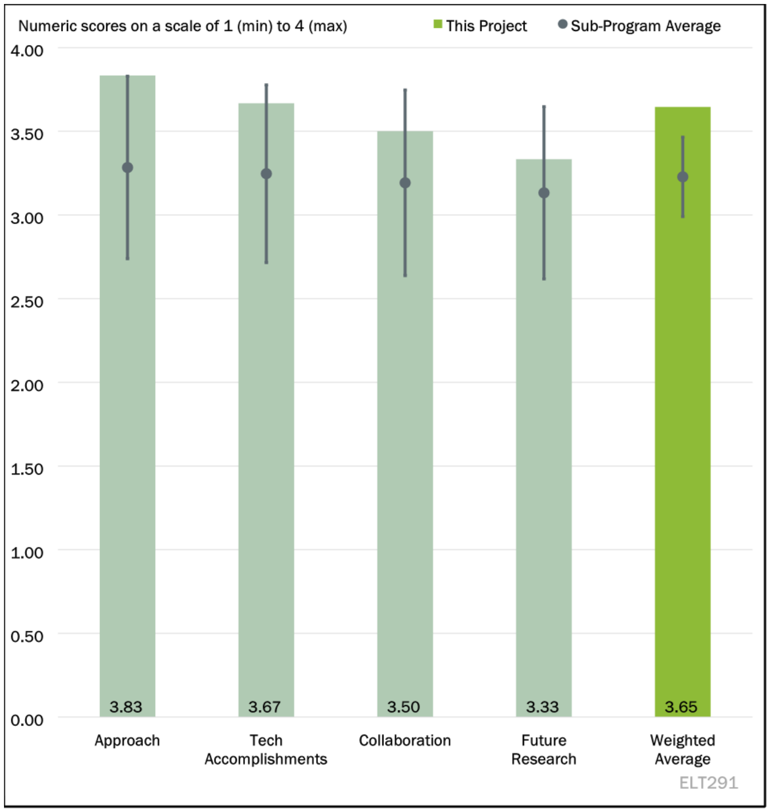

Figure 2-33 - Presentation Number: ELT291 Presentation Title: Enabling Extreme Fast Charging with Energy Storage Principal Investigator: Jonathan Kimball (Missouri University S&T)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer said that the university led project’s workflow is logical and as per engineering practices. Early on the project team placed focused efforts on a proof-of-concept followed by full-scale prototype resulting in a pathway for system integration and field testing to evaluate developed technology in a near real-world application. Power conversion system is designed using well known concept of dual-active bridge.

Reviewer 2:

The reviewer said this project clearly focuses on numerous technical barriers including reduced battery degradation during high-speed charging and reducing grid impacts during high-power charging.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer said clear technical progress has been accomplished after the necessary technical shift to using 480V in place of 1.5kV.

Reviewer 2:

The reviewer said the workflow for the proposed extreme fast charger with energy storage includes assessment of grid compatibility, development of power conversion, and battery charging. Control system of overall power conversion system is included in the projects’ AMR report. As per project report and AMR presentation, project team utilizes grid, energy storage, and network of vehicles in overall eco system of XFC charger and their locations to suppress power quality and power availability impacts. Cost analysis is carried out by project team indicating 18.87% cost saving. A low voltage prototype was developed and tested. The reason for falling back on low voltage prototype was unavailability for the medium voltage devices. The project team developed a Raspberry Pi based supervisory control system and outlined future work. A 1MW station prototype pictures are included in project's AMR report and 100kVA charging current waveforms also included in the project's AMR report. Constant lithium plating current (constant dQ_{Li}/dt) constant voltage (CQtCV) charging algorithm is described in the project's AMR report. Single Module XFC Thermal Testing carried out and temperature data included in the project's AMR report.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer said strong collaboration exists in execution of project activities.

Reviewer 2:

The reviewer remarked the project has assembled good partners that cover all the technical areas required for a successful project.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer said the project is currently finalizing integration and field testing followed by plan for analyzing field results.

Reviewer 2:

The reviewer remarked the proposed future work appears to list the previous completed accomplishments from budget period 1 and budget period 2. The budget period 3 tasks work are also listed. Consider future work to include a field demonstration of this charging infrastructure with an electrified fleet to verify the successful benefits even during edge use cases such as a wide range in ambient temperature, fleet utilization (charge time, duration, duty-cycle), and variable distribution feeder conditions.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer said this project is relevant to VTO's sub-program in electrification and will accelerate adoption of EVs.

Reviewer 2:

The reviewer stated the project supports the objectives by improving battery resiliency during fast recharging while reducing grid impacts.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said the project has necessary resources and research funds.

Reviewer 2:

The reviewer remarked that this project successfully completed the deliverables with the allocated resources.

Acronyms and Abbreviations – ELT

Abbreviation	Definition
3D	Three-dimensional
AAM	American Axle and Manufacturing
AC	Alternating current
ACM	American Center for Mobility
AMR	Annual Merit Review
ANL	Argonne National Laboratory
ASIC	Application-specific integrated circuit
ASPIRE	Advancing Sustainability through Powered Infrastructure for Roadway Electrification
ATD	ATEAM Transmission Distribution
ATEAM	Agent-based Transportation Energy Analysis Model
BEV	Battery electric vehicle
BGE	Baltimore Gas and Electric
BMS	Battery management system
BTM	Behind the meter
CARB	California Air Resources Board
CIM	Common information model
CNG	Compressed natural gas
CQtCV	Constant lithium plating current (constant dQ_{Li}/dt) constant voltage
DAB	Dual active bridge
DBC	Direct bonded copper
DC	Direct current
DCFC	Direct current fast charger
DER	Distributed energy resource(s)
DHAM	Dual rotor homopolar AC machine
DOE	U.S. Department of Energy
DRIVE	U.S. DRIVE
DVI	Drive vehicle interface
DVP&R	Design validation plan and report
DWPT	Dynamic wireless power transfer

Abbreviation	Definition
EDM	Electric drive machine
ELT	VTO Electrification Technologies subprogram
EERE	Office of Energy Efficiency and Renewable Energy
EMC	Electromagnetic compatibility
EMF	Electromagnetic field
EMI	Electromagnetic interference
i-EMS	Intelligent energy management system
EPA	U.S. Environmental Protection Agency
EPRI	Electric Power Research Institute
ESS	Energy storage system
EV	Electric vehicle
EVSE	Electric vehicle supply equipment
FCET	Fuel cell electric truck
FCEV	Fuel cell electric vehicle
FTP	Federal Test Procedure
GHG	Greenhouse gas
H2	Hydrogen
HATCI	Hyundai America Technical Center, Inc
HD	Heavy-duty
HRE	Heavy rare earth
HV	High voltage
ICE	Internal combustion engine
ID	Identification
IEC	International Electric Code
IGBT	Insulated gate bipolar transistor
IIMo	Institute of Innovative Mobility (Germany)
IIT	Illinois Institute of Technology
INL	Idaho National Laboratory
IPM	Integrated power module
kW	Kilowatt
LFP	Lithium iron phosphate

Abbreviation	Definition
LLC	Limited liability corporation
LMO	Lithium-ion manganese oxide
LTO	Lithium titanium oxide
MCS	Megawatt charging system
MV	Medium voltage
MVA	Megavolt-ampere
MW	Megawatt
NCSU	North Carolina State University
NHTSA	National Highway Traffic Safety Administration
NMO	Nickel manganese oxide
NMC	Nickel manganese cobalt
NMC622	6:2:2 ratio nickel manganese cobalt oxide
NREL	National Renewable Energy Laboratory
NSP	Network service provider
NYPA	New York Power Authority
ODBC	Organic direct bonded copper
OEM	Original equipment manufacturer(s)
ORNL	Oak Ridge National Laboratory
PEV	Plug-in electric vehicle
PECO	Formerly Philadelphia Electric Company
PI	Principal investigator
PM	Permanent magnet
R&D	Research and development
RDD&D	Research, development, deployment, and demonstration
SAE	SAE International, formerly known as the Society of Automotive Engineers
SCAQMD	South Coast Air Quality Management District
SCM	Smart charge management
SEMS	Site energy management system
SiC	Silicon carbide
SSCB	Solid-state circuit breaker

Abbreviation	Definition
SST	Solid-state transformer
SUNY	The State University of New York
SUPER	Scalable ultra power-dense extended range
T	Tesla
TCO	Total cost of ownership
TIM	Thermal interface material
TPG	Thermal pyritic graphite
TRL	Technology readiness level
TTSI	Total Transportation Services, Inc.
UPER	Universal power electronics regulator
US06	EPA US06, also known as the Supplemental Federal Test Procedure
SFTP	Supplemental Federal Test Procedure
V2G	Vehicle to grid
VGI	Vehicle grid integration
VTO	Vehicle Technologies Office
VTTI	Virginia Tech Transportation Institute
WAVE	Wireless Advanced Vehicles Electrification
WBG	Wide bandgap
WFSM	Wound-field synchronous machine
WLTC	Worldwide Harmonized Light Vehicles Test Cycle
WPT	Wireless power transfer
WXFC	Wireless extreme fast charge
XFC	Extreme fast charge
XIL	Everything-in-the-loop
ZECT	Zero emission cargo transport

3. Decarbonization of Off-Road, Rail, Marine, and Aviation Technologies

The Vehicle Technologies Office (VTO) supports research, development, demonstration, and deployment (RDD&D) of new, efficient, and clean mobility options that are affordable for all Americans. The office's investments leverage the unique capabilities and world-class expertise of the national laboratory system to develop new innovations in vehicle technologies, including: advanced battery technologies; advanced materials for lighter-weight vehicle structures and better powertrains; energy-efficient mobility technologies and systems (including automated and connected vehicles as well innovations in connected infrastructure for significant systems-level energy efficiency improvement); innovative powertrains to reduce greenhouse gas (GHG) and criteria emissions from hard to decarbonize off-road, maritime, rail, and aviation sectors; and technology integration that helps demonstrate and deploy new technology at the community level. In coordination with the other offices across the Office of Energy Efficiency and Renewable Energy (EERE) and the U.S. Department of Energy (DOE), VTO advances technologies that assure affordable, reliable mobility solutions for people and goods across all economic and social groups; enable and support competitiveness for industry and the economy/workforce; and address local air quality and use of water, land, and domestic resources.

The Decarbonization of Off-Road, Rail, Marine, and Aviation (DORMA) Technologies subprogram supports RDD&D to develop and deploy new propulsion and efficient vehicle technologies in off-road, rail, marine, and aviation applications that reduce GHG emissions and achieve a net-zero economy by 2050, all while creating good paying jobs with the free and fair chance to join a union and bargain collectively.

The goal of this portfolio is to conduct coordinated research with industry, universities, and the national laboratories through cooperative research and development agreements (CRADAs).This subprogram conducts industry-led RDD&D for off-road medium and heavy-duty (HD) vehicles, including engines used for marine, rail, and aviation, focused on electrified and hybrid systems as well as powertrains that can utilize renewable fuels, such as advanced biofuels, H_2, renewable diesel and e-fuels. The subprogram will coordinate with and utilize expertise from other Offices and VTO programs as needed.

The subprogram supports cutting-edge research at the national laboratories, in close collaboration with industry, while working closely with other agencies including the Environmental Protection Agency and Department of Transportation's Federal Railroad Administration (FRA) and Maritime Administration (MARAD), to achieve goals for decarbonization of these subsectors. It will use a multi-laboratory initiative, including high performance computing (HPC) and hardware in-the-loop resources, for research to optimize vehicle efficiency which also will be applicable to hard to electrify on-road HD vehicles.

The subprogram also supports industry needs to develop predictive, high-fidelity sub-models and simulation tools that are scalable and can leverage future exascale computing capabilities. The activity will fund research of renewable fuel properties utilizing chemical kinetics modeling of different molecules to determine their impact on combustion efficiency and emissions. It will also develop numerical routines and sub-models of complex chemical reactions that can reduce the computational time and increase the accuracy required for high-fidelity engine models, making them viable for use by industry.

Project Feedback

In this merit review activity, each reviewer was asked to respond to a series of questions, involving multiple-choice responses, expository responses where text comments were requested, and numeric score responses (on a scale of 1.0 to 4.0). In the pages that follow, the reviewer responses to each question for each project will be summarized: the multiple choice and numeric score questions will be presented in graph form for each project, and the expository text responses will be summarized in paragraph form for each question. A table presenting the average numeric score for each question for each project is presented below.

Table 3-1 – Project Feedback

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
DORMA001	Heavy-Duty H_2 Combustion	Ales Srna (Sandia National Laboratories)	3-6	3.42	3.50	3.58	3.58	3.50
DORMA002	Off-Road Liquid Fuel Combustion	Dario Lopez-Pintor (Sandia National Laboratories)	3-12	3.29	3.43	3.43	3.36	3.38
DORMA003	High-Fidelity Simulations of Swirl-Stabilized Spray Flame with Sustainable Aviation Fuels	Bruno Souza Soriano (Sandia National Laboratories)	3-18	3.38	3.75	3.13	3.50	3.55
DORMA004	Ducted Fuel Injection	Chuck Mueller (Sandia National Laboratories)	3-23	3.60	3.60	3.60	3.60	3.60
DORMA005	Sprays and Spray Combustion	Lyle Pickett (Sandia National Laboratories)	3-27	3.75	3.75	3.75	3.58	3.73
DORMA006	LLCF combustion and emission models	Scott Wagnon (Lawrence Livermore National Laboratory)	3-32	3.58	3.58	3.50	3.42	3.55
DORMA007	Innovative NO_x Reduction Materials for Low Temperature Aftertreatment	Yong Wang (Pacific Northwest National Laboratory)	3-37	3.30	3.20	3.30	3.10	3.23
DORMA008	Slashing Platinum Group Metal (PGM) in Catalytic Converters: An Atoms-to-Autos Approach	Kevin Gu (General Motors)	3-41	3.10	3.10	3.60	3.00	3.15
DORMA009	NO_x Reduction with Low GHG Impact (N_2O Reduction for Off-road)	Feng Gao (Pacific Northwest National Laboratory)	3-45	3.20	3.10	3.20	3.00	3.13
DORMA010	Hardware in the Loop Toolkit for Off-Road and Marine	Muni Biruduganti (Argonne National Laboratory)	3-50	2.70	2.20	2.30	2.60	2.39

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
DORMA012	H_2 Combustion Research – CRADA with Wabtec	Muhsin Ameen (Argonne National Laboratory)	3-55	3.25	3.50	3.50	3.50	3.44
DORMA013	Experimental and Numerical Research on Biodiesel and Renewable Diesel Blends for Locomotive Engines	Chao Xu (Argonne National Laboratory)	3-57	2.75	2.75	3.25	2.75	2.81
DORMA014	Implementing low lifecycle carbon fuels on locomotive engines – CRADA with Wabtec	Dean Edwards (Oak Ridge National Laboratory)	3-59	3.50	3.25	3.50	3.00	3.31
DORMA015	Enabling H_2 and Methanol Combustion	Riccardo Scarcelli (Argonne National Laboratory)	3-62	3.00	2.67	2.17	3.00	2.73
DORMA016	Renewable methanol-fueled engines for marine and off-road applications	Jim Szybist (Oak Ridge National Laboratory)	3-65	3.33	3.67	3.33	3.50	3.52
DORMA017	SAF End Use Research	Sibendu Som (Argonne National Laboratory)	3-68	3.38	3.25	3.13	3.50	3.30
DORMA018	SAF Combustion & Soot Processes	Julien Manin (Sandia National Laboratories)	3-72	3.25	3.38	3.00	3.00	3.25
DORMA019	Multi-phase flow studies of SAFs for industry-relevant conditions and geometries	Brandon Sforzo (Argonne National Laboratory)	3-76	3.17	3.67	3.50	3.17	3.46
DORMA020	SAF Contrail Modeling	Matt McNenly (Lawrence Livermore National Laboratory)	3-80	3.63	3.13	3.50	3.13	3.30
DORMA021	Simultaneous Greenhouse Gas and Criteria Pollutants Emissions Reduction for Off-Road Powertrains	James McCarthy (Eaton)	3-85	3.67	3.33	3.33	3.67	3.46

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
DORMA022	Development of a Flex-Fuel Mixing Controlled Combustion System for Gasoline/Ethanol Blends Enabled by Prechamber Ignition	Adam Dempsey (Marquette University)	3-88	3.75	3.75	3.75	3.38	3.70
DORMA023	Improved Efficiency of Off-Road Material Handling Equipment through Electrification	Jeremy Worm (Michigan Technological University)	3-92	3.75	3.50	3.63	3.38	3.56
DORMA024	Reduced Cost and Complexity for Off-Highway Aftertreatment	Ken Rappe (Pacific Northwest National Laboratory)	3-96	3.50	3.50	3.83	3.33	3.52
DORMA025	Fully Electric Powered, Hydraulic Assisted, Compact Track Loader	Perry Li (University of Minnesota)	3-99	3.30	3.10	3.40	3.40	3.23
DORMA026	Articulated Dump Truck (ADT) Electrification – Greenhouse Gas Reductions and Commercialization of New Technology	Brij Singh (John Deere)	3-104	3.17	3.00	3.17	3.17	3.08
DORMA027	LLCF Effects on Emissions Control Catalyst Performance and Durability	Sreshtha Sinha Majumdar (Oak Ridge National Laboratory)	3-107	3.40	3.50	3.30	3.60	3.46
DORMA028	Comprehensive Integrated Simulation Methodology for Enabling Near-Zero Emission Heavy-Duty Vehicles	Andrea Strzelec (University of Wisconsin-Madison)	3-112	3.50	3.75	3.50	3.75	3.66
DORMA029	Fast Simulation of Real Driving Emissions from Heavy-duty Diesel Vehicle Integrated with Advanced Aftertreatment System	Hailin Li (West Virginia University)	3-115	3.33	2.83	3.50	3.50	3.13
DORMA030	Opposed-Piston 2-Stroke Hybrid Commercial Vehicle System	Fabien Redon (Achates Power)	3-118	2.83	2.83	3.33	2.83	2.90

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
DORMA031	Dynamic Skip Fire (DSF) on a Heavy-Duty Natural Gas Engine	Jay Shah (Cummins)	3-121	3.50	3.25	3.00	3.00	3.25
DORMA032	High Efficiency, Ultra Low Emissions Heavy-Duty 10L Natural Gas Engine Project	Tim Lutz (Cummins)	3-125	3.50	3.50	2.13	3.50	3.33
DORMA033	High Pressure Fast Response Direct Injection System for Liquified Gas Fuels Use in Light-Duty Engines	William de Ojeda (WM International Engineering)	3-129	3.50	3.60	3.60	3.30	3.54
DORMA034	Low-Mass and High-Efficiency Engine for Medium-Duty Truck Applications	Qigui Wang (General Motors)	3-133	3.13	3.00	3.38	3.33	3.12
DORMA035	Next-Generation, High-Efficiency Boosted Engine Development	Michael Shelby (Ford)	3-136	3.88	3.63	3.50	3.33	3.64
DORMA036	SuperTruck 2 – PACCAR	Maarten Meijer (PACCAR)	3-139	3.70	3.60	3.70	3.60	3.64
DORMA037	SAF Specifications and Testing Protocols, Gina Fioroni, National Renewable Energy Laboratory	Gina Fioroni (National Renewable Energy Laboratory)	3-143	3.30	3.30	3.60	3.20	3.33
DORMA038	Towards Accurate Reacting Flow Simulations of SAFs	Debolina Dasgupta (Argonne National Laboratory)	3-149	3.20	3.40	3.00	3.30	3.29
Overall Average				3.36	3.32	3.32	3.29	3.33

Presentation Number: DORMA001
Presentation Title: Heavy-Duty H_2 Combustion
Principal Investigator: Ales Srna (Sandia National Laboratories)

Presenter

Ales Srna, Sandia National Laboratories

Reviewer Sample Size

A total of six reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 83% of reviewers felt that the resources were sufficient, 17% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

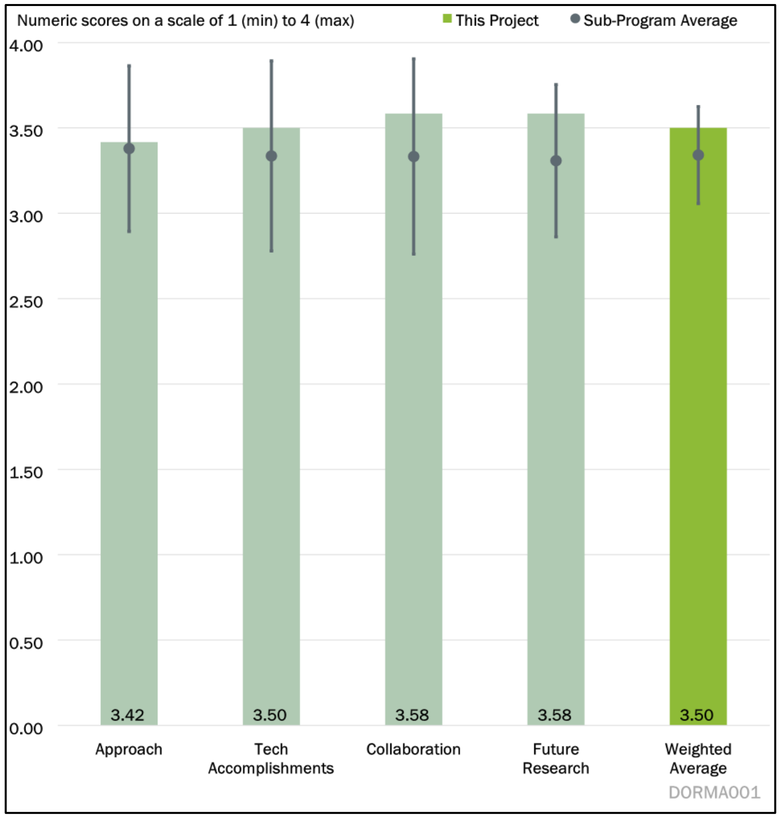

Figure 3-1 – Presentation Number: DORMA001 Presentation Title: Heavy-Duty H_2 Combustion Principal Investigator: Ales Srna (Sandia National Laboratories)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer believed this project was well designed and has the major barriers for hydrogen (H_2) internal combustion engine (ICE) systems identified. The reviewer stated that the gaps and barriers listed toward predictive H_2 combustion simulations are correct as well as the understanding that most original equipment manufacturers (OEMs) are pursing H_2 ICE heavily. The reviewer also said that the listing of knowledge gaps is a nice way to lay out the “why” behind the approach. Further, the Fiscal Year (FY) 2022 completed deliverables give evidence toward the excellent approach and feasibility.

Reviewer 2:

The reviewer stated that this is a very focused fundamental investigation of the mixing and combustion characteristics of H_2 in a heavy-duty (HD) engine, and it will provide foundational knowledge that could be very helpful in the refinement of H_2 use in the HD mobility sector. The phenomenon being investigated will be somewhat specific to the approach being taken. The reviewer commented that the researchers are likely aware of this and have plans to explore other approaches of introducing and burning H_2 in the engine, for example via prechamber systems.

Reviewer 3:

The reviewer said that this is a well-designed project with a reasonably planned timeline.

Reviewer 4:

The reviewer believed this project is a good start to close the fundamental research and development knowledge gaps by addressing some of the key technical barriers—from basic understanding of air management system requirements to the in-cylinder processes and predictive simulations of the combustion processes of H_2-fueled internal combustion engines.

Reviewer 5:

The reviewer believed that this project is focused on understanding the H_2 combustion in H_2 ICE. The reviewers stated that the researchers developed the single cylinder engine with several *in situ* measurement/characterization tools and used condition ranges similar to those in practical operations. The reviewer said that the key value of this project is that it provides visualization of the combustion (which they state is almost impossible in a real-life system), provides mechanical understanding of the process, and provides good data for modeling. The reviewer indicated that the project is well designed and the timelines are reasonably planned. The reviewer stated that there is a possibility that the project could have a Phase 2 depending on whether there are additional questions that need to be addressed based on the current work.

Reviewer 6:

The reviewer said that this this project has done an excellent job of defining and exploring the challenges of HD H_2 combustion, starting from the basics of injector and mixing behavior to including H_2 preignition.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer said that quantitative measurements of H_2 concentration, H_2-air mixing, and ignition clearly achieved the deliverables listed toward overcoming the barriers. The quantitative output in the database is incredibly useful for internal combustion engine research and development, simulation validation, and physics understanding. The reviewer stated that the linkage of this data for 0-dimensional (0D) and 1-dimensional (1D) model development is very useful and the publication of this data and efforts on the Engine Combustion Network (ECN) website could bring broad dissemination. The reviewer commented that the cyclic variability of H_2-air mixture preparation is very important to understand (for preignition, operation limits, design influences, etc.) and encouraged the quantitative data to include as much variability and uncertainty understanding as possible. The reviewer pointed out that the preignition root cause work appeared to be coming along nicely with examples of how the phenomena can be grouped and what parameters impact the probability. The reviewer believed that the potential of this project is to use optical diagnostics to see what is happening, combine that new information with other analyses (like 0D kinetic calculations), and provide a better understanding of the combustion preignition. The reviewer advised that the researchers continue to focus on gaining knowledge and fully explaining the mechanisms on the full range of preignition root causes.

Reviewer 2:

The reviewer stated that the work completed so far (and reported in the first Annual Merit Review) is of very high caliber.

Reviewer 3:

The reviewer said that the researchers did a great job keeping the project on track. The reviewer also commented that the project has good methods to understand in-cylinder phenomena as well as promising findings (e.g., the importance of temperature for H_2 preignition).

Reviewer 4:

The reviewer stated that reasonable technical progress had been made based on the results from the optical engine in the areas of in-cylinder mixing, flame evolution, and hot-spot preignition mixing, which are critical to abnormal combustion challenges in H_2-fueled internal combustion engines, such as backfire. However, the moderate range of injection pressure (20–40 bar) being investigated is very limited since this will cover only low-pressure H_2 combustion concepts. The reviewer advised that the project scope be expanded to include high-pressure combustion concepts that require an injection pressure of 250–300 bar to reflect the long-term viable systems that will be required to meet diesel-like engine efficiency and ultra-low emissions for commercial implementation.

Reviewer 5:

The reviewer remarked that the research team had documented the database of cylinder H_2 direct injection mixture formation in HD optical engines. The reviewer also stated that the team established a connection between various parameters of engine operation, such as injection pressure on mixture formation and flame kernel evolution.

Reviewer 6:

The reviewer stated that there have been many valuable outcomes from this project, including correlations of nitric oxide (NO) and nitrogen dioxide (NO_2) formation and mixing, showing that preignition can be triggered and controlled, showing shock-like behavior during H_2 injection, and the origins of cyclic variability.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer stated that the collaboration between Sandia National Laboratories (SNL), the Advanced Engine Combustion (AEC) working group, industry, the European universities, and other U.S. national laboratories demonstrates the near maximum amount that could be achieved for a project of this size.

Reviewer 2:

The reviewer recommended that the researchers enlist the participation of injector suppliers, as the injection system is critical to the phenomena being investigated. The reviewer gave Westport as an example, given that the reviewer believed that Westport is developing direct injection H_2 systems.

Reviewer 3:

The reviewer stated that while the collaboration and coordination across the project team was outstanding, Principal investigators and DOE program managers should try to increase the participation of universities in the United States for such projects. The low level of government funding for academic research will result in more universities ending any research on decarbonization other than electrification (despite recognizing that there are many sectors difficult to electrify). The reviewer said that this could end any student training on decarbonization strategies other than electrification.

Reviewer 4:

The reviewer praised the fantastic collaboration and coordination work under the AEC working group between the national laboratories (Sandia National Laboratories and Argonne National Laboratory), academia (University of Duisburg-Essen, Polytechnic University of Valencia, and Danish Technical University), and industry (Borg Warner, Cummins, Caterpillar, Detroit Diesel Corporation, Mack Trucks, Volvo, GE, PACCAR, and Gamma Technologies).

Reviewer 5:

The reviewer said that the extent of the collaborations meets expectations and is appropriate for a DOE national laboratory-led project. There are built-in opportunities for sharing information and interaction with stakeholders through the AEC-memorandum of understanding group. The reviewer remarked that while collaborations were mentioned with two European universities, none were mentioned with any U.S. universities. This could be an area to expand with the growing interest in basic research on H_2 applications.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer remarked that future particle image velocimetry (PIV) measurements to aid in the flow field development and ignition/kernel development will be very powerful for physical understanding and computational fluid dynamics (CFD) model validation. The reviewer recommended continued addition of quantitative measurements to build a robust canonical H_2 internal combustion engine data set. The reviewer then stated that having "pre-chamber" on the list for future H_2 efforts is an excellent decision and it makes sense that the project budget and scope could not include everything in the initial stages. The reviewer went on to say that evaluation of the different H_2 ICE "combustion" and "injection technology" options, and how the physics are impacted, is desirable within the project. However, the reviewer encouraged the project to stay away from technology selection for H_2 ICE. The reviewer approved of the plans to add lubrication to the H_2 preignition understanding and stated that the addition of an oil injection device seems like a very reasonable way to reproduce interesting phenomena in a controlled manner in the skip-fired optical engine.

Reviewer 2:

The reviewer commented that the project is still in an early stage, though the team has interesting results already. The reviewer agreed with the team's assessment that the planned next phase of the research is the appropriate path to follow.

Reviewer 3:

The reviewer said that the team has done a very good job ensuring that the next milestones are achieved successfully.

Reviewer 4:

The reviewer stated that the future research plans to expand the scope to investigate ignition systems and wall-heat loss, as well as to upgrade the HD optical engine facility, should also factor into the exploration of higher injection pressures and other sources of preignition, like lubrication.

Reviewer 5:

The reviewer remarked on how the project team highlighted the work they planned for next year and based on the progress, should be able to achieve the project's goals in time.

Reviewer 6:

The reviewer said that the project's progress to date will be continued and expanded on in the future as well as in the long-term plans for the project. Considering optimization of the injection and mixing processes in concern with chamber geometry should lead to additional impactful outcomes. The reviewer remarked that the consideration of wall effects is a very good expansion and continuation of the project scope, as the literature has documented how sensitive H_2 ignition can be to surface interactions.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer commented that the project is 100% relevant and aligned to DORMA goals. The reviewer also stated that the project is nicely aligned to the industry need to quickly learn and develop H_2 ICE for customers who wish to show their intentions toward low carbon dioxide (CO_2) power systems.

Reviewer 2:

The reviewer acknowledged that the HD sector will be difficult to turn into an electric vehicle-only sector. H_2 has the potential to overcome many of the constraints impeding the adoption of battery electric vehicles in this sector. The reviewer stated that a detailed fundamental understanding of the subtleties of H_2 combustion in HD engines will help manufacturers decide if this is a viable option for their HD propulsion systems.

Reviewer 3:

The reviewer said that the project effectively addresses the VTO goals of reducing GHG emissions from off-road HD vehicles.

Reviewer 4:

The reviewer stated that this project supports the overall VTO objectives in DORMA.

Reviewer 5:

The reviewer commented that H_2 ICE is seen as the bridge between diesel, natural gas ICE, and fuel cell technology. As there are several logistical and durability challenges regarding the wide-scale implementation of fuel cell technology in HD transportation, H_2 ICE can fill the gap as the “engine” and “technology” are more familiar to the end customer, and service networks are more mature. In addition, there are several platforms where H_2 fuel cells would be difficult to make roads because of the thermal management constraints. The reviewer went on to say that there may be additional challenges for fuel quality due to the source of H_2 production and pipeline transport. Therefore, H_2 ICE can fill the gap and help in the decarbonization of HD transportation.

Reviewer 6:

The reviewer praised the project, stating that the outcomes are significant to date, and hopes for more to come.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that this project needs to expand to investigate additional types of H_2 combustion strategies, and faster. The reviewer went on to say that the project is underfunded and needs just as much effort as competing H_2 energy conversion programs, such as the fuel cell programs. The reviewer advised reallocation toward H_2 ICE projects like this, as ICE will be the first adopter of H_2 in many areas prior to fuel cells.

Reviewer 2:

The reviewer observed that the research team made a comment in passing that there were some aspects of the project that could have been pursued, but they were not included because of the resources. However, it appears that the resources are sufficient for the work that is planned.

Reviewer 3:

The reviewer remarked that it is difficult to comment on project resources when DOE funding for such projects is very limited.

Reviewer 4:

The reviewer stated that the resources for the project are sufficient based on the spend rate for completed work and the future work being planned.

Reviewer 5:

The reviewer said that the funding level seems consistent with expectations for a typical project using optical diagnostics in combustion research.

Presentation Number: DORMA002
Presentation Title: Off-Road Liquid Fuel Combustion
Principal Investigator: Dario Lopez-Pintor (Sandia National Laboratories)

Presenter

Dario Lopez-Pintor, Sandia National Laboratories

Reviewer Sample Size

A total of seven reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

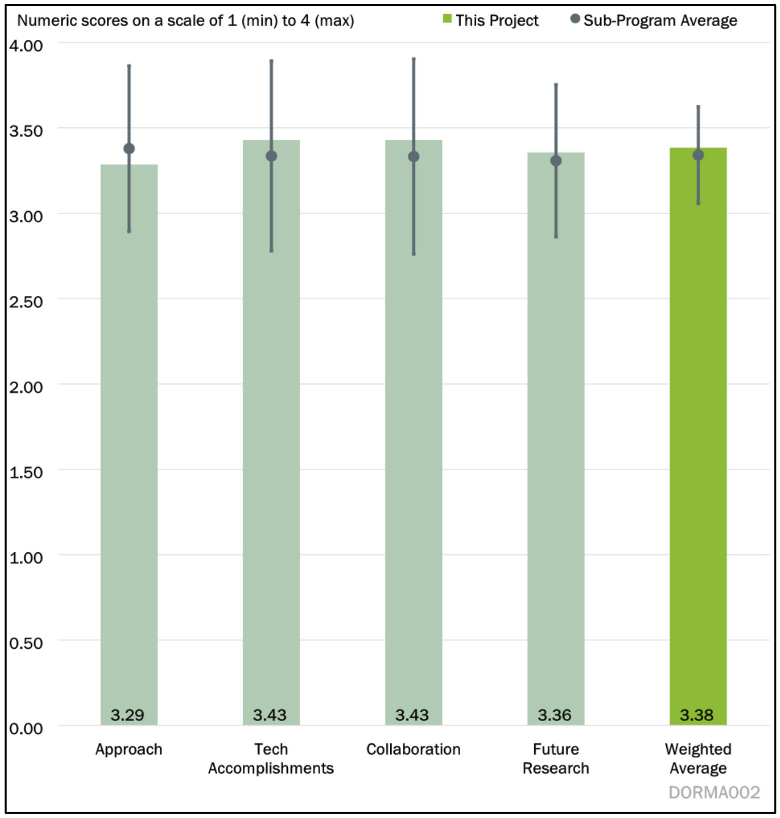

Figure 3-2 - Presentation Number: DORMA002 Presentation Title: Off-Road Liquid Fuel Combustion Principal Investigator: Dario Lopez-Pintor (Sandia National Laboratories)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer stated that the approach of utilizing existing laboratory capabilities for MD and HD mixing-controlled compression ignition (MCCI) engines allow for quick and flexible research and development. In addition, coupling optical engines to the research enables insight into the combustion processes not otherwise achieved through metal engines or simulations. The reviewer believed that the strategy used to compare alcohol fuels to diesel fuels is an excellent way to impart this knowledge to industry as well as internal combustion engine research and development collaborators. The reviewer also commented that consideration for retrofit and conversion of existing internal combustion engine architectures for low-carbon fuel MCCI combustion is critical for off-road, and this project has identified potential retrofitting concepts.

Reviewer 2:

The reviewer was unsure as to why this research is being done. There have been many studies published on the literature using ethanol and methanol with ignition improvers to achieve MCCI. The reviewer failed to see a difference between this work and what has already been reported in said literature.

Reviewer 3:

The reviewer’s principal concern was with the high levels of ignition improvers that are needed to provide reasonable compression ignition (CI) combustion with the alcohol fuel. The reviewer stated that the potential cost of this approach in practice is concerning.

Reviewer 4:

The reviewer said that the project is well-designed with a reasonably planned timeline.

Reviewer 5:

The reviewer stated that the project is well designed with appropriate scope, focusing on ethanol and methanol, and is on track to address the listed technical barriers within the planned timeline.

Reviewer 6:

The reviewer expressed that improving the understanding of liquid injection, ignition, and combustion behavior for non-petroleum-based fuels is an important topic and has been a focus of DOE-funded research for quite some time. The connections between engine and vehicle companies are a strength, as are the broad collaborations that have been listed in the presentation. The justification that MCCI combustion is broadly essential in off-road applications, is consistent with the general viewpoint of the industry. The reviewer went on to say that there has already been quite a bit of work done in the past on ethanol and methanol in CI engines, so at the outset of the presentation, the reviewer wondered what new information is needed in this space for these short-chain alcohol fuels. Engines have been commercialized, and current efforts by companies such as ClearFlame are considering novel approaches to using ethanol in CI engines. The reviewer approved of the approach to better understand fuel mixing, air utilization, and pollutant formation. However, the reviewer noted that the additive enhanced approach that has been the focus of the first year is of limited practical value. The Scania approach of using a 5% or more additive mixture in ethanol has seemed to be a commercial dead end, though the ClearFlame approach seems much more likely to be effective in the long run.

Reviewer 7:

The reviewer affirmed that the project considers the technical challenges associated with the use of low-carbon fuels in attaining clean and efficient combustion in modern engines. The project focuses on the fuel property effects on nitrogen oxides (NO_x) and particulate emissions. The reviewer observed that the project team points out the need to improve the database for these fuels to support the existing simulation tools. The choice to focus on ethanol and methanol is reasonable, as they represent the most promising fuel candidates. The reviewer admitted that more work is needed to advance their use in model diesel engines due primarily to their low ignitability, especially as the target is to demonstrate superior performance with respect to diesel.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer noted that the achievement of stable and successfully robust combustion with 2-ethlyhexyl nitrate (2-EHN) doped ethanol is very clearly demonstrating quick and useful demonstration data for feasibility. The focus on low-load operation is very good, as ignition stability will be limited at the lower in-cylinder pressures and temperatures. The reviewer also stated that the initial progress on ozone (O_3) addition for ignition enhancement is interesting and demonstrates exploration into areas less researched. The reviewer praised the insight on the sensitivity difference between ethanol and methanol.

Reviewer 2:

The reviewer stated that while the experimental work appears sound, there does not appear to be any new knowledge being generated. To date, the results have been only a basic exploratory experimental effort. The reviewer commented that there are four collaborators who will do CFD work, but even though the project is approximately 50% complete there does not seem to be any results from these collaborators.

Reviewer 3:

The reviewer said that the experiments and modeling work provide very interesting results and advised that the project team prepare technical papers on these results. The reviewer also praised the extensions to higher compression ratios, ozone addition, and alternative cetane improvers.

Reviewer 4:

The reviewer stated that the principal investigator did a great job keeping the project on track and praised the methods to understand in-cylinder phenomena, remarking that these were promising findings.

Reviewer 5:

The reviewer praised the progress being made compared to the project plan, demonstrating promising results from ethanol MCCI combustion with different levels of ignition improver. The only suggestion the reviewer had for the project team was to generate similar results over a much broader operating range.

Reviewer 6:

The reviewer remarked that the accomplishments to date are limited in some respects by the scope of the initial efforts to focus on an extremely high-level of ignition improver addition. The reviewer went on to say that these levels of additives are extreme and impractical, though the fact that such mixtures perform well as CI fuels is a useful outcome.

Reviewer 7:

The reviewer stated that the use of ignition improvers to enable ethanol and methanol mixing control combustion in a diesel engine is an effective approach, proven commercially in a European application. The merit relies on no new hardware needed for the engine. The reviewer said that this work provides tests results with 2-EHN for the ignition improver on a single cylinder engine at two representative test points, with results showing potential to improve the diesel baseline. The reviewer commented that the results are very comprehensive, reporting thermal efficiency, particulate matter, and NO_x emissions.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer praised the excellent collaboration being demonstrated through the OEM) collaborations for the laboratory engine and the in-progress cooperative research and development agreement (CRADA). The reviewer also said that the simulation collaboration with five universities is excellent and quite substantial.

Reviewer 2:

The reviewer was unsure how to evaluate this question. The reviewer stated that there was no discussion of interaction with the collaborators, yet the list shows that there are multiple collaborators. The reviewer pointed out that the industry collaborators were not discussed in any detail and questioned whether they were technically engaged or just providing hardware and technical support.

Reviewer 3:

The reviewer commented that one slide describes collaborators, though the connections are not entirely clear.

Reviewer 4:

The reviewer stated that the project demonstrated very good collaboration and coordination across the project team.

Reviewer 5:

The reviewer said that that the collaboration and coordination between the national laboratories, universities, and industry stakeholders is well documented with clearly defined contributions from the project partners.

Reviewer 6:

The reviewer commented that the connections between engine and vehicle companies is a strength, as are the broad collaborations that have been listed in the presentation.

Reviewer 7:

The reviewer noted that the research team gathered industrial partners, national laboratories, and several universities, each contributing their own expertise to the project.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer indicated that the proposed future research is generally good and consistent with the off-road goals. Pulling in off-road OEM voices through the industry CRADAs will help orient the future research to off-road-unique requirements. The reviewer commented that the more generic the future research is, the better the accomplishments will be for the highly varied off-road ICE landscape (i.e., 1 L/cylinder to +20 L/cylinder engines).

Reviewer 2:

The reviewer stated that if the proposed work was accomplished it could be helpful, but according to the timeline provided, the reviewer was worried that the project team will not be able to complete the considerable work that lays ahead, especially the optical diagnostics and its collaboration with CFD.

Reviewer 3:

The reviewer observed that alternative ignition improvers are mentioned in the project and wondered if lower-cost compounds would provide acceptable performance. The reviewer noted that the "Future Research" slide mentioned studying the mixture preparation of ethanol/methanol in an optical engine, which appears to overlap with DORMA005, though no collaboration is mentioned.

Reviewer 4:

The reviewer praised the job done by the research team to ensure that next milestones are achieved successfully.

Reviewer 5:

The reviewer commented that the project is on track to meet the planned milestones, given its 55% completion rate. The purpose of the work to be completed as well as the proposed future research is clearly defined and will continue to enhance the fundamental understanding of the impact of low carbon fuels on combustion and emissions processes.

Reviewer 6:

The reviewer stated that the planned exploration of dimethyl ether (DME) and diethylene glycol diethyl ether as ignition improvers is a good expansion of the study, though this has already been done in the early 1990s (it was the first application of DME in an engine study). The reviewer commented that the mixed alcohol studies are a good extension of the work and stated that the practical ignition and tribological impacts of the alcohol mixtures need to be a part of this work if it is to yield valuable practical guidance. While much can be learned from the planned research, the reviewer questioned whether it would impact future engine design.

Reviewer 7:

The reviewer observed that the project effectually outlines concrete steps, including metal and optical engine testing, as well as CFD modeling.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer commented that the project is well aligned to the DORMA program objectives to help off-road ICE engines reduce CO_2 emissions as it is off-road focused with MCCI. However, the use of an MD on-road truck engine platform does bring in questions about applicability to off-road engines and the different operating regimes. The reviewer asked that the project team try to minimize the influence of on-road engine aspects and on-road input.

Reviewer 2:

The reviewer stated that in principle the work addresses the VTO program objective. Based on what was presented, the reviewer did not see that it will significantly advance the understanding from what is currently available in the literature. For example, the reviewer said, there was a very interesting paper presented at Thiesel 2020, “Renewable Energy to Power through Net-Zero-Carbon Methanol; R. Durrett and M. Potter, GM Global Research and Development, Warren, Michigan, USA,” which lays out an engine configuration of an MCCI methanol engine and has some very interesting potential.

Reviewer 3:

The reviewer agreed that it would be great to use the lower alcohols directly in direct injection and ICE engines.

Reviewer 4:

The reviewer stated that the project addresses VTO goals of using sustainable fuels for reducing emissions from off-road HD engines.

Reviewer 5:

The reviewer affirmed that this project supports the overall VTO subprogram objectives for DORMA.

Reviewer 6:

While much can be learned from the planned research, the reviewer questioned whether it would impact future engine design. The reviewer commented that using extremely high treat rates if ignition improves is a dead end. Dual fuel combustion is already practical and can be implemented widely if desired. The reviewer recommended that the researchers consider a dual direct injection strategy to combine these alcohol mixtures with available biofuels for compression ignition engines.

Reviewer 7:

The reviewer stated that ethanol and methanol are promising candidates for decarbonization. Additionally, the reviewer said that the project focuses on “fundamental understanding” to enable MCCI combustion with these fuels and demonstrate equivalent, or superior, performance to that of petroleum diesel fuel.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer acknowledged that the funding and resources seem appropriate to keep the ICE laboratory functioning but encouraged DOE to equally fund research and development for ICE at similar levels to the less feasible efforts on electrification.

Reviewer 2:

The reviewer commented that there was no indication the project is constrained by resources.

Reviewer 3:

The reviewer stated that the resources appear fine.

Reviewer 4:

The reviewer said it was difficult to comment on project resources when DOE funding for such projects is very limited.

Reviewer 5:

The reviewer stated that based on the spend rate and work completed to date, as well as the work to be completed, the resources for the project should be sufficient.

Reviewer 6:

The reviewer believed the funding level seem appropriate for a typical engine research study at the national laboratories.

Presentation Number: DORMA003
Presentation Title: High-Fidelity Simulations of Swirl-Stabilized Spray Flame with Sustainable Aviation Fuels
Principal Investigator: Bruno Souza Soriano (Sandia National Laboratories)

Presenter

Bruno Souza Soriano, Sandia National Laboratories

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

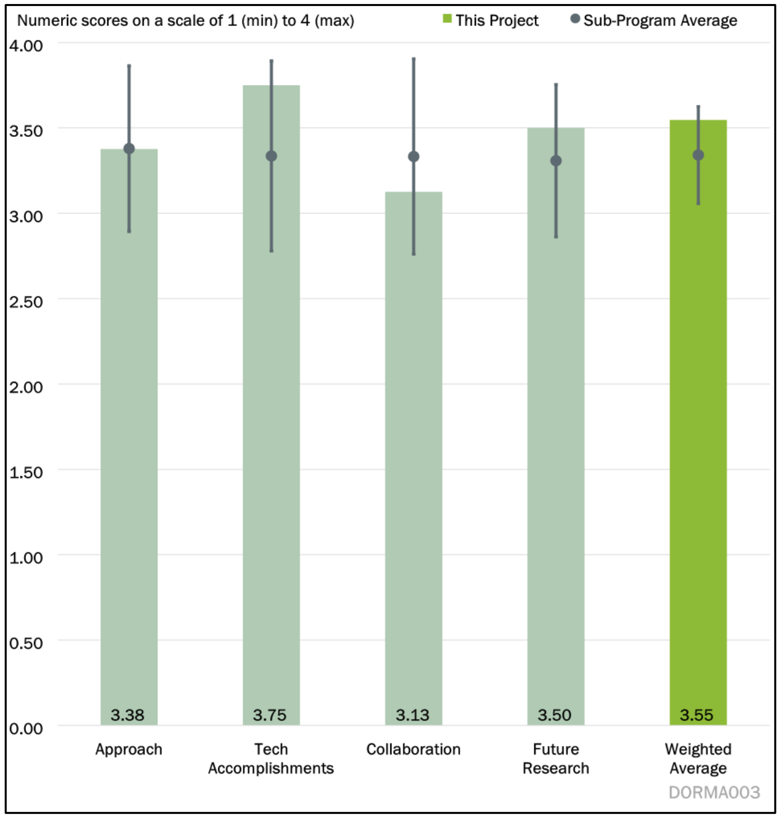

Figure 3-3 - Presentation Number: DORMA003 Presentation Title: High-Fidelity Simulations of Swirl-Stabilized Spray Flame with Sustainable Aviation Fuels Principal Investigator: Bruno Souza Soriano (Sandia National Laboratories)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer stated that the approach taken for the simulations is clearly effective and cutting edge. The reviewer believed that the project is following the right technical approach. However, the reviewer cautioned that the learnings from this project will be extremely sensitive to engine technology and operating conditions. For example, sprays at relevant compressor discharge conditions will be very different than at atmospheric conditions. Sprays and combustion physics in a rich-quench-lean (RQL) combustor will be very different than in a GE combustor. The reviewer praised the different corners of the space covered in the presentation and recommended an up-front “test matrix” that shows how different conditions and different hardware are explored, and what the research team aims to learn from each of these.

Reviewer 2:

The reviewer agreed that flame extinction and reignition are indeed a critical problem to address in the aviation industry. The reviewer commented that the project is correctly focusing on characterization of various jet fuels by performing large eddy simulations (LES) and direct numerical simulations (DNS). The reviewer also mentioned that this is not a big enough project to solve all the barriers, yet it is a critical step.

Reviewer 3:

The reviewer commented that the research team is using state-of-the-art computational methods to investigate swirl-stabilized spray flames.

Reviewer 4:

The reviewer pointed out that the timeline for this project was noted as having a start date of October 2022 and an end date of September 2023, though it is still not clear if this is the last year of the project. The reviewer said that the project involved modeling using the Pele computational framework to address (ultimately) multicomponent liquid evaporation, flame stabilization, and soot formation at high pressures in combustors relevant to the aviation industry. The configurations considered are a single-hole atomizer (SHA) and an LES of a lean direct injection (LDI) burner. The reviewer went on to make the following additional comments:

In practical burners, fuel is injected as a spray, and the SHA droplets will also be present. It was not clear how the presence of droplets and multicomponent evaporation would be considered for a fuel like Jet A or a sustainable aviation fuel (SAF) which will contain hundreds of components. A single component hydrocarbon seems not to be appropriate as a Jet A surrogate, as seems to be assumed here.

The most common approach is to pre-vaporize the liquid to rid the complication associated with coupling the chemistry of ignition with fuel droplet evaporation processes (e.g., shock tubes, flow reactors, etc.). The gas composition is the same as the originally prepared surrogate composition at the injection plane. The reality of the problem may be very different where the heat release at the flame evaporates the fuel, as in real combustors. While there may be conditions where the multicomponent SAF flash evaporates to create an initial fuel mixture of the same composition as the SAF at the injection plane, what those conditions are were not discussed in the presentation. One of the photos in the presentation clearly showed droplets well downstream of the fuel injection port.

Models for droplet evaporation typically consider an isolated droplet. It is not evident that such models would be applicable to configurations like a spray or even an SHA, because of droplet-to-droplet interactions that are typically present.

If the SHA does not produce monodispersed droplets, it was not clear how a distribution of droplets would be considered in the fuel evaporation analysis.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer stated that the project is highly accomplished. The major computational framework appears to be fully established. The reviewer also found the post-processing and data analysis to be well matured and insightful.

Reviewer 2:

The reviewer commented that performing a DNS study of a laboratory-scale combustor provides invaluable information to understand the combustion dynamics better. The reviewer said that this is an excellent attempt and progress report. The reviewer also stated that more complex geometry with LES was a natural and reasonable choice.

Reviewer 3:

The reviewer praised the technical progress and stated that while the modeled configurations do not have all the characteristics of gas-turbine swirl-stabilized combustors, there is a lot to be learned from the computation results.

Reviewer 4:

The reviewer stated that the lift-off length simulations for Jet A and C1 showed substantial differences for the probability density function and robust capabilities of the model. The reviewer also commented that the simulations of the mixing lengths were shown and were quite interesting. The reviewer did not think it was clear whether the fuel phase was pre-vaporized gas with no liquid droplets present. If details at the level of individual droplets were not possible to incorporate in the simulations, the reviewer wondered if the future work would consider how droplets alter the results. The reviewer was intrigued by the fact that the simulation results (white boundaries in Slide 7) seem to follow the trajectories of the flame edge and diffusion flame boundaries. The reviewer noted that the project is shown to be 70% complete, which is a good place to be at this point.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer said that the presentation did a nice job laying out the various partners and collaborators up front and identifying their areas of contribution. The reviewer remarked that the partners nicely covered the DNS for near-field combustion dynamics experiments, soot modeling, and kinetics. The reviewer was particularly fascinated by the edge-flame dynamics. In the reviewer’s opinion, there is a gap with the spray modeling, though the reviewer also observed that the project is producing its own contributions on that front. Overall, the reviewer believed that this is a good team with good partners, but the “checks and balances” of the spray model was a weakness.

Reviewer 2:

The reviewer had nothing to criticize, stating that the collaboration is well organized with essential parties.

Reviewer 3:

The reviewer approved of the collaboration with Cambridge University and the experimentalists at Sandia National Laboratories (SNL). The reviewer also noted that there appears to be some collaboration with modeling efforts at other institutions as well.

Reviewer 4:

The reviewer affirmed that the project team includes five partners: NREL, The University of Cambridge, Princeton University, The University of Illinois Urbana-Champaign (UIUC), and Stanford University. The reviewer stated that the Cambridge collaboration was the easiest to follow in the presentation. The reviewer noted that UIUC and Stanford were both to provide a “chemical mechanism,” but they were not clear on what this chemical mechanism was and how it would be developed. The reviewer also stated that it was not clear what the Princeton soot modelling effort would provide, where it fits, and how it would be used in the project. The reviewer recommended that any future presentations articulate the deliverables of each of the collaborators to make it clear how the parts effectively contribute to the whole.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer stated that the proposed future research nicely covers the gaps seen as the accomplished work was being presented. In particular, the measurements of soot and spray will be critical to validate and refine this work. In the reviewer’s opinion, the project has identified the right future work to validate the contributions of the project.

Reviewer 2:

The reviewer commented that the extension of the current accomplishments to more complex geometries while scaling up the physical domain is a natural and plausible choice.

Reviewer 3:

The reviewer stated that the proposed future research looks very interesting. Improvement of flamelet models and better modeling of the spray are very important and the reviewer approved of them being included in the future work plan. The reviewer also noted that SHA experiments are not representative of sprays for aviation gas turbines, but are interesting, nonetheless.

Reviewer 4:

The reviewer observed that the future work plan notes several challenges and barriers that would be addressed, including the need for improved kinetic mechanisms, incorporation of soot chemistry, and additional information to characterize the spray boundary. The reviewer stated that these are logical and appropriate, and being cast in such general terms, the overarching way forward is evident. However, the reviewer said, any one of the above can require a substantial effort, and details of the approach for future modeling was not clear. As the reviewer noted, this study would have significant separation from the “state of the art” on fuel spray injection if the liquid and gas were considered as a fully coupled system. The reviewer further noted that this approach has only been possible for isolated droplet burning with capabilities to incorporate soot, radiation, and a plethora of other factors, but evidently not for a SHA or spray flame.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer stated that soot formation is a highly relevant component of SAF end use. In fact, according to the reviewer, many speculate that it might even be an advantage to SAFs, with environmental and heat transfer (durability) benefits. However, the reviewer noted, the ability to simulate gas turbine soot emissions is relatively immature today. The reviewer went on to say that this project is directly filling the need not only for SAFs, but also for the combustion system engineering community as a whole. Additionally, the insight that this project is producing on flame stabilization details is valuable and the reviewer hoped that it will be fed over to Dasgupta (DORMA038).

Reviewer 2:

The reviewer believed that the project supports the objective of reducing emissions by adopting alternative jet fuels.

Reviewer 3:

The reviewer stated that this project supports the objectives for the DORMA subprogram.

Reviewer 4:

The reviewer remarked that the project is quite relevant from a broad perspective, with renewed interest in combustion technologies using SAFs.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented that the resources for this project look appropriate, so long as the partners are bringing sufficient cost share and doing relatively few new experiments. The reviewer noted that the project identified a need for future work to obtain spray and soot data, and the reviewer agreed with this need, but anticipated a higher funding level will be needed for those partners to conduct those types of tests.

Reviewer 2:

The reviewer stated that the resources are sufficient.

Reviewer 3:

The reviewer remarked that the research team has performed a great deal of work for the annual budget of $150,000.

Reviewer 4:

The reviewer believed that a budget of $150,000 is quite modest for the work being carried out. The reviewer said that the research team appears to already have significant computational infrastructure, allowing them to produce the results presented in a short amount of time. The reviewer also mentioned that it was not noted how the five other collaborators were supported in the project.

Presentation Number: DORMA004
Presentation Title: Ducted Fuel Injection
Principal Investigator: Chuck Mueller (Sandia National Laboratories)

Presenter

Chuck Mueller, Sandia National Laboratories

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

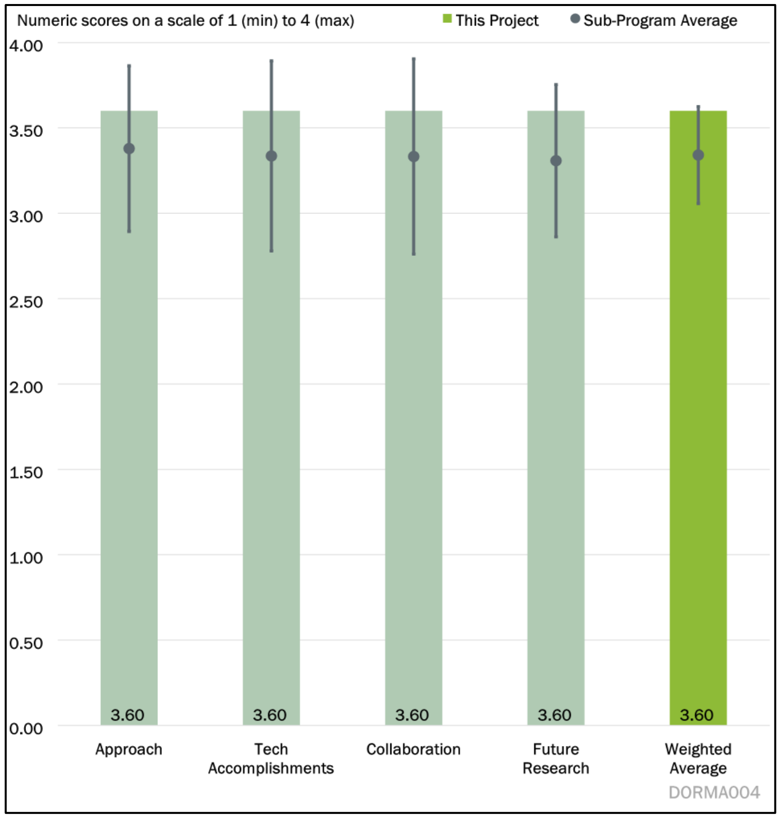

Figure 3-4 - Presentation Number: DORMA004 Presentation Title: Ducted Fuel Injection Principal Investigator: Chuck Mueller (Sandia National Laboratories)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer stated that the alignment of ducted fuel injection (DFI) to low carbon fuels makes sense in relation to DOE goals. The reviewer commented that the traditional diesel fuel DFI needs just as much focus as the low carbon fuels, as diesel will continue to be used for decades in long-life offroad power systems. To aid the approach, the reviewer suggested making comparisons to continuous-fired single cylinder engines and state-of-the-art diesel engine combustion and emissions, as it is sometimes hard to tell the real relevance of the DFI emissions results.

Reviewer 2:

The reviewer praised the project, saying it is potentially game-changing work. The reviewer said it represents a project which is moderate risk with a huge potential payoff. For a transportation sector that will be difficult to convert to electric vehicles (EVs), this technology, if proven to be applicable, will be a game changer. The reviewer stated that not only will there be a reduction in the CO_2 associated with carbon reduction in the fuel, but it could also yield improved performance of the engine, as well as significantly reduce criteria pollutants with less expensive aftertreatment systems.

Reviewer 3:

The reviewer commented that the project presented an interesting technology. The reviewer stated that the higher-load optical operation with DFI provides excellent insights. The reviewer also said that some extended (metal engine) operation would be useful in order to understand longer operation durability.

Reviewer 4:

The reviewer stated that this was a well-designed project with a reasonably planned timeline and an outstanding approach to understanding the issues.

Reviewer 5:

The reviewer commented that this project, which mainly focuses on DFI technology, has been well designed and has made a significant impact to the overall understanding of clean combustion, in particular the reduced engine-out NO_x and particulate emissions, as well as fuel effects on soot formation and oxidation processes. However, the reviewer stated, with only 70% of the project completed it might be quite a challenge to meet the planned project completion timeline.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer stated that upgrading the optical engine to allow for higher peak cylinder pressures demonstrates very clear delivery and accomplishment. This is critical to move into the relevant state space for HD ICEs and future research and development. The reviewer approved of the quantitative soot reduction with DFI compared to conventional diesel combustion as well as the move toward including the rest of the combustion system (e.g., piston bowl) into the DFI optimization, which the reviewer said is well warranted. The reviewer also stated that the understanding of heat-loss increase from DFI shows good progress toward a holistic understanding of how DFI impacts combustion, emissions, and engine efficiency. The reviewer then commented that the heat transfer impact should be investigated with an entire combustion system DFI optimization and stated that it is unclear what the Wabtec FOA2197 technical progress is, or if it should even be reported in this project review.

Reviewer 2:

The review praised the results, saying that the fundamental understanding of the results is yielding insight into the enhanced potential of DFI and possible further improvements. The reviewer also stated that demonstrating the potential of DFI at high load was a great accomplishment.

Reviewer 3:

The reviewer noted that the project had made excellent progress and stated that the misalignment and design variable study would be important to complete and publish.

Reviewer 4:

The reviewer stated that the research team did a great job keeping the project on track. The reviewer praised the methods to understand in-cylinder phenomena as well as the promising findings (e.g., the use of DFI and oxygenated fuels can reduce aftertreatment requirements).

Reviewer 5:

The reviewer praised the accomplishments and progress that had been made compared to the project plan, with successful demonstration of large reductions in engine-out soot, NO_x, and CO_2 emissions with sustainable oxygenated fuels in an optical engine over a broad range of full-load conditions.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer said that the collaboration between U.S. and international entities shows excellent engagement and interest in the ICE and combustion community.

Reviewer 2:

The reviewer observed that the groups who have been brought into the collaboration effort are exploring a deeper understanding of the fundamentals as well as its use in multi-cylinder operation and its integration into a production engine.

Reviewer 3:

The reviewer stated that the collaboration appears good, and there was not much discussion during the presentation.

Reviewer 4:

The reviewer commented that while collaboration and coordination across the project team was outstanding, principal investigators and DOE program managers should try to increase the participation of U.S. universities in such projects. The low level of government funding for academic research will result in more universities ending any research on the decarbonization topic other than electrification (despite recognizing that there are many sectors difficult to electrify). According to the reviewer, this could end student training on any decarbonization strategies other than electrification.

Reviewer 5:

The reviewer praised the collaboration and coordination between national laboratories (Sandia National Laboratories), academia (Bandirma University–Turkey, and Georgia Tech–USA), and industry stakeholders (Aramco, British Petroleum, Chevron, Clean Fuels Alliance America, Coordinating Research Council, Cummins, Daimler Truck, Denso, ExxonMobil, Ford, General Motors, Honda, John Deere, Mercedes, Phillips 66, Shell, Toyota, Wabtec, and Southwest Research Institute). The reviewer commented that these were very well done.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer stated that the proposed idea to reduce NO_x and particulate matter formation without exhaust gas recirculation (EGR), but with DFI and oxygenated fuels is very interesting. Efforts made towards quickly evaluating the real feasibility of this would be beneficial, as the physics of NO_x mitigation seem highly challenging but would be more impactful than solely soot reduction. The reviewer stressed the need for this project to continue moving towards understanding and demonstrating multi-hole DFI performance across the ICE operating range. This could be with diesel or low carbon fuels. The reviewer went on to say that strategies, as well as a fundamental DFI mechanism understanding for real HD MCCI systems, are needed to go from optical/canonical combustion systems to real world systems. These would need to work at many different ambient and boundary conditions (e.g., what happens when starting a DFI engine at –40°C?).

Reviewer 2:

The reviewer affirmed that the project team is aware of the challenges that lay ahead and acknowledged that the team has laid out a coherent plan to address them.

Reviewer 3:

The reviewer stated that the companion CFD modeling would be useful to aid in the understanding of design variable effects (e.g., number of holes and diameter).

Reviewer 4:

The reviewer praised the work done by the project team to ensure that the next milestones are achieved successfully.

Reviewer 5:

The reviewer commented that the proposed future research has a clearly defined purpose and will likely achieve its targets based on the results that have been demonstrated so far. For successful commercial implementation, the reviewer recommended that the scope of future work include an understanding of cold start capability with DFI technology.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer stated that the project is relevant, given that it continues progressing DFI in case there are any breakthroughs. The reviewer also admitted that it seems to be a stretch to tie low carbon fuels to DFI given that many of the fuels are already oxygenated and produce a low amount of soot, or zero soot.

Reviewer 2:

The reviewer reiterated that the project represents potentially game-changing work, stating that it presents only moderate risk with a huge potential payoff.

Reviewer 3:

The reviewer was fascinated by the approach to lower soot, and perhaps increased maximum engine loads.

Reviewer 4:

The reviewer commented that the project addresses the VTO goal of reducing emissions from off-road HD engines.

Reviewer 5:

The reviewer stated that the project supports the overall VTO subprogram objectives for DORMA.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said that the funding is at an appropriate level to continue observing the project for breakthroughs.

Reviewer 2:

The reviewer stated that the work appears to be proceeding well with the resources available, though the reviewer wondered what might happen if more resources were directed at the practical implementation. The reviewer asked if it was possible to know if this is a candidate for production engines at a sooner date?

Reviewer 3:

The reviewer remarked that the resources appear to be sufficient.

Reviewer 4:

The reviewer noted that it is difficult to comment on project resources when DOE funding for such projects is very limited.

Reviewer 5:

The reviewer stated that the resources for this project are sufficient based on the spend rate for completed work and the proposed future research.

Presentation Number: DORMA005
Presentation Title: Sprays and Spray Combustion
Principal Investigator: Lyle Pickett (Sandia National Laboratories)

Presenter

Lyle Pickett, Sandia National Laboratories

Reviewer Sample Size

A total of six reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 83% of reviewers felt that the resources were sufficient, 17% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

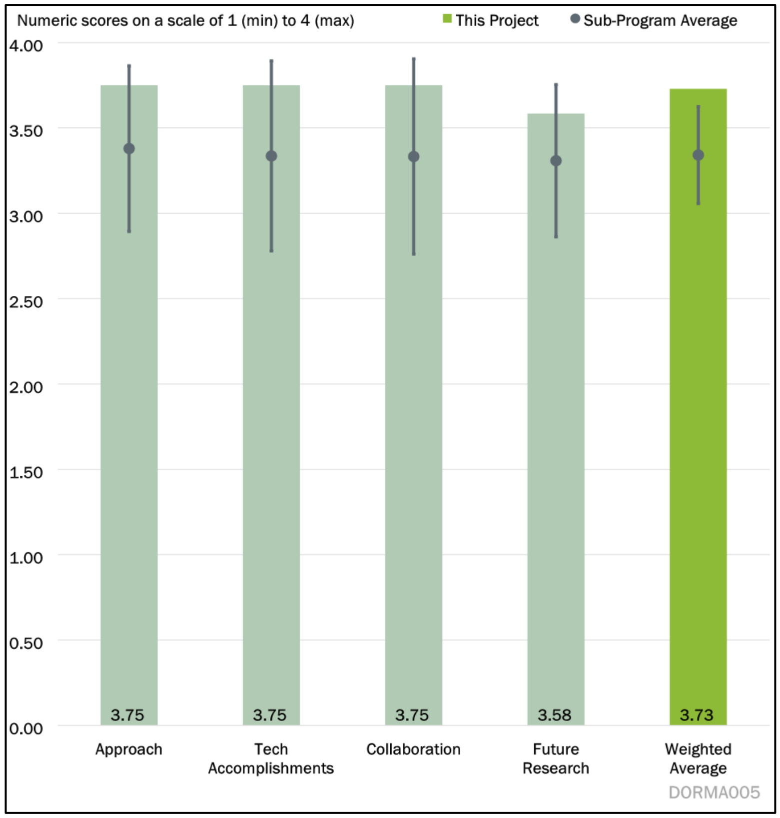

Figure 3-5 - Presentation Number: DORMA005 Presentation Title: Sprays and Spray Combustion Principal Investigator: Lyle Pickett, (Sandia National Laboratories)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer said that the approach of multiple industry CRADAs, Advanced Engine Combustion (AEC) working group oversight, and worldwide engagement via ECN activities enables multiple pathways and resources to tackle the project goals. The reviewer commented that the discussion of the motivation for this work makes sense, and the methodical thinking aids in the excellence of the approach. The reviewer agreed with the decision to continue using the ECN approach to build quantitative datasets from world class laboratories and resources, as this drives broad ICE community learning. The reviewer praised the approach to move sprays from single isolated jets to multi-jets and more realistic combustion chambers, as more complicated physics can be understood.

Reviewer 2:

The reviewer observed that the project had been reconfigured to use the accumulated knowledge from the ECN to consider the behavior of low carbon fuel in spray combustion systems.

Reviewer 3:

The reviewer stated that most of the presentation focused on the excellent experimental work, and the only piece that appeared to be missing was the feedback-connection from the empirical work to the spray modeling. The reviewer also commented that the multiple spray plume interaction observation was very interesting. The reviewer expressed interest in how the physics of this effect are, or may be, captured by the modeling.

Reviewer 4:

The reviewer said that the project is well-designed with a reasonably planned timeline.

Reviewer 5:

The reviewer said that the project is well designed with a reasonable timeline to address some of the barriers associated combustion systems optimized for sustainable fuels with particular emphasis on methanol, renewable, diesel, and H_2.

Reviewer 6:

The reviewer commented that project relies on an outstanding experimental capability that has helped to improve the understanding of injection and combustion processes and, in the present work, is continuing to make important observations to address future engine design.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer stated that the demonstration of a sootless methanol HD MCCI spray/flame is an outstanding quantitative result that pushes the traditional understanding of a fuel-rich jet's sooting propensity. The reviewer commented that this aids in computational validation efforts greatly, and it also illuminates technology strategy comparisons to other ICE investigations, like ducted fuel injection (DFI). The reviewer further stated that liquid length quantification of methanol is another critical point of understanding for combustion and fuel system development. The investigation of the sprays for port or low-pressure direct injection (DI) low-carbon fuel combustion systems is, according to the reviewer, very useful for fundamental injector design understanding. The reviewer also commented that the quantitative learning here can be applied broadly. The reviewer noted that it was very interesting to see how the methanol sprays differ from gasoline-like fuels, and the addition of heat flux measurements and wall impingement adds outstanding capability. Finally, the reviewer praised the technical accomplishments, stating that they are coming along quickly in this multifaceted project.

Reviewer 2:

The reviewer remarked that the project represents very fundamental work. The reviewer also commented on how the research team not only explained the fundamental findings—they also explained the implications of these findings in more general take-aways. For example, the differences in spray behavior between methanol and gasoline and what this means in terms of oil dilution, wall wetting, crankcase ventilation, and soot formation.

Reviewer 3:

The reviewer believed that this newer area of characterizing and understanding DI methanol injection will be very important for future HD low-carbon methanol fueled engines. The reviewer also stated that this project's technical experimental work, with its various diagnostics, provides an outstanding comprehensive picture of the DI methanol spray.

Reviewer 4:

The reviewer stated that the research team did a great job keeping the project on track. The reviewer praised the methods used to understand spray phenomena, stating that the findings were promising.

Reviewer 5:

The reviewer approved of the technical progress made compared to the project plan, stating that the results were very promising, providing insights on critical spray combustion metrics that will enable improvements in modeling and commercial implementation of sustainable fuel injection.

Reviewer 6:

The reviewer commented that this project has provided key new insights on the injection behavior of renewable diesel fuel. Given the enormous commercial interest in renewable diesel fuel, this is an outstanding combination of developing fundamental measurements to help support the development of clean, low-GHG, and practical solutions.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer stated that modeling the ECN framework and adding multiple CRADAs demonstrates a benchmark for DOE programs. There is no higher standard than this.

Reviewer 2:

The reviewer was impressed by the list of collaborators and their contributions.

Reviewer 3:

The reviewer noted that the presentation appeared to focus mainly on the Sandia Spray Groups' contributions. Partners were mentioned (on one slide), but the degree of interaction was not immediately clear.

Reviewer 4:

The reviewer commented that while collaboration and coordination across the project team was outstanding, Principal investigators and DOE program managers should try to increase the participation of U.S. universities in such projects. The low level of government funding for academic research will result in more universities ending any research on the decarbonization topic other than electrification (despite recognizing that there are many sectors difficult to electrify). According to the reviewer, this could end student training on any decarbonization strategies other than electrification.

Reviewer 5:

The reviewer praised the collaboration and coordination between national laboratories, academic institutions, and industry stakeholders. The reviewer commented that the contributions from all project partners were clearly defined and very well done.

Reviewer 6:

The reviewer stated that this project supports excellent collaborations and enables broad interactions with groups and industry around the world. This is a model for how to maximize impact.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer stated that adding a move toward H_2 injection makes complete sense as the liquid low-carbon fuel research is already covered by the program. The reviewer remarked that the H_2 injection likely depends highly on the injector technology as well as the strategy. The usefulness of the H_2 quantitative spray data for modelling, including 1D/3D, CFD, etc., is invaluable. However, the reviewer believed that trying to get away from injector design-specific behavior would benefit the ICE community most.

Reviewer 2:

The reviewer commented that the work discussed and the assessment of what should be done in the future represents a coherent path for continuing to enhance the fundamental understanding of the phenomena governing combustion behavior of low carbon fuels, while also giving insight into what the practical challenges for engine development will be.

Reviewer 3:

The reviewer said that the future work section mainly focused on the upcoming H_2 fuel injection work. The reviewer also stated that the methanol spray results were outstanding and encouraged the researchers to finish and publish this part of the project.

Reviewer 4:

The reviewer stated that the research team did a very good job up to this point, ensuring that the next milestones are achieved successfully.

Reviewer 5:

The reviewer remarked that purpose of the remaining challenges and barriers, as well as the proposed future research, are clearly defined and the project is on track to achieve its stated targets. The reviewer praised the team, asking that they continue the good work.

Reviewer 6:

The reviewer commented that the move to consider H_2 is highly topical and should provide important insights into how to improve H_2 fuel injections systems, engines, and combustion processes.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer stated that this project is completely relevant for the DORMA goal of enabling low-carbon sustainable fuels for ICE and combustion systems.

Reviewer 2:

The reviewer commented that this work will inform engine developers and combustion system researchers trying to use low-carbon fuels in the transportation sector which will not be easily converted into electric vehicles.

Reviewer 3:

The reviewer said that the project is quite relevant to current engine and fuel development trends and efforts.

Reviewer 4:

The reviewer stated that the project addresses the VTO goal of reducing GHG emissions from off-road HD, while also supporting the production of sustainable fuels.

Reviewer 5:

The reviewer said that the project supports the overall VTO subprogram objectives for DORMA.

Reviewer 6:

The reviewer commented that this work has impact and is highly relevant to the application of low-carbon intensity fuels.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that ICE will be the fastest way to reduce carbon emissions and move toward a sustainable energy source. The reviewer encouraged DOE to add resources and funding to this ICE research and not put all hopes into electrification.

Reviewer 2:

The reviewer said that there was no indication that the resources were limiting the progress of this project.

Reviewer 3:

The reviewer remarked that the resources appear to be sufficient.

Reviewer 4:

The reviewer noted that it is difficult to comment on project resources when DOE funding for such projects is very limited.

Reviewer 5:

The reviewer stated that the resources for this project are sufficient based on the spend rate for completed work and the proposed future research.

Reviewer 6:

The reviewer said that the resources seem appropriate for this type of optical fuel injection and combustion research.

Presentation Number: DORMA006
Presentation Title: LLCF combustion and emission models
Principal Investigator: Scott Wagnon (Lawrence Livermore National Laboratory)

Presenter

Scott Wagnon, Lawrence Livermore National Laboratory

Reviewer Sample Size

A total of six reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

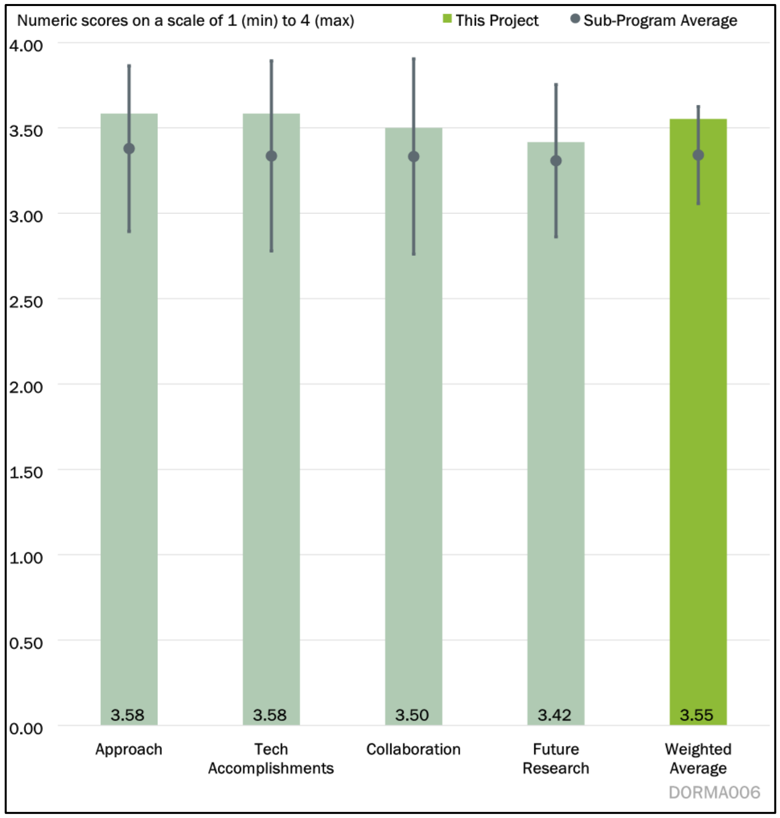

Figure 3-6 - Presentation Number: DORMA006 Presentation Title: LLCF combustion and emission models Principal Investigator: Scott Wagnon (Lawrence Livermore National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer stated that the project's approach continues the time-tested kinetic mechanism development process that Lawrence Livermore National Laboratory (LLNL) has pioneered, among others, throughout the decades. The reviewer saw the approach as likely to deliver the goals and address the barriers identified. The reviewer approved of the focus on solvers as well as the focus on both kinetic models for oxidation and emissions.

Reviewer 2:

The reviewer stated that this is important work. The researchers are following an established and proven approach to increasing the kinetic understanding and fidelity of the resultant models for simulation of the ignition and flame characteristics of low-lifecycle carbon fuels.

Reviewer 3:

The reviewer agreed that LLNL does excellent work in this area, expanding the mechanisms for various hydrocarbons (HCs). However, the reviewer also wondered if part of the research team's future effort should include some "automated" mechanism generation tool development. That being said, the reviewer was not sure if this is possible from first principles. The reviewer also stated that there are so many HCs, and now hydrogen-based molecules, that perhaps a way to auto-generate would be more efficient in the future.

Reviewer 4:

The reviewer stated that the project is well-designed and has a reasonably planned timeline.

Reviewer 5:

The reviewer commented that the project is reasonably well-designed to address some of the technical barriers to meet the stakeholder’s need for chemical kinetic models that accurately predict combustion models and can run quickly in CFD simulations. However, the reviewer said, the approach for performing the work is based on current best practices of traditional approaches, but in order to achieve the desired simulation speeds, the team should also investigate non-traditional approaches. This could include neural network and machine learning algorithms that have shown “order of magnitude” efficiency improvement when employed in the characterization of material properties.

Reviewer 6:

The reviewer observed that this project continues a long-term effort of improving the understanding and characterization of combustion chemistry. The reviewer stated that the application to improving kinetic mechanisms for SAF is highly topical and important for the present push to roll out low carbon intensity aviation. The reviewer commented that this is extremely useful work with demonstrated impacts in the science and engineering of combustion and fuels.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer stated that the progress on utilization of unique universal identifiers seems quite good to standardize the pallets of surrogate components within the kinetics research community. The focus on methyl alkane is clear in its relation to low-lifecycle-carbon fuel (LLCF) and sustainability. The reviewer commented that the ignition delay comparisons seem adequate for the current state (26% complete) of the project but noted that it would be good to link the ignition delay errors to relevant ICE error success criteria to precisely know the needed accuracy for ICE combustion modeling. The reviewer further stated that the agreement in asymptotic behavior of C8-C80 methyl alkanes for flame speed seemed to agree quite well with the qualitative behavior or the data in the literature, which is very powerful for showing the correct physics prediction behavior. Similarly, the reviewer said, the soot model work and comparisons to soot volume fraction data from the University of Connecticut looked very good, as soot modeling is incredibly difficult. In closing, the reviewer commented that the end-users of many of the developed mechanisms rely on reduced mechanisms, so the progress on an automated reduction process demonstrated great progress toward adoption and impact of this project’s mechanism efforts.

Reviewer 2:

The reviewer observed that the researchers are systematically developing, and updating, the needed kinetic mechanisms for detailed modeling on LLCFs.

Reviewer 3:

The reviewer said that these are very useful mechanisms that are made publicly available and encouraged the team to publish the physical basis for mechanism reductions.

Reviewer 4:

The reviewer stated that the research team did a great job keeping the project on track and accomplishing the goals.

Reviewer 5:

The reviewer commented that the technical progress made compared to the project plan is reasonable but the number of LLCFs in scope may be too broad for the project timeline.

Reviewer 6:

The reviewer observed that the project has updated and rolled out surrogate fuel formulations and kinetic mechanisms for design and development of SAF, which may be comprised of lightly methylated compounds.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer stated that the multiple collaborations with other national laboratories, universities, and software companies demonstrates excellent collaboration which will drive adoption and use by the ICE community.

Reviewer 2:

The reviewer observed that the research team is interacting with the international community to discuss, evaluate, and improve their kinetic models.

Reviewer 3:

The reviewer commented that the collaboration efforts appear to be fine.

Reviewer 4:

The reviewer said that the researchers demonstrated excellent collaboration and coordination across the project team.

Reviewer 5:

The reviewer stated that the project shows broad collaboration and coordination between national laboratories, academic institutions, and industry stakeholders.

Reviewer 6:

The reviewer praised the broad and impactful collaborations, stating that the project is a model for how to maximize the impact of combustion chemistry research.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer stated that the proposed future research seems good and agreed with the question about adding efforts to gain validation data and model development at high pressures and with EGR. They said that this could be added to the future scope of work with specific tasks.

Reviewer 2:

The reviewer observed that the research team had identified the important chemistry subgroups, C8–C20 2-methylalkanes, that need to be incorporated into the kinetic models to facilitate the modeling effort of low-carbon fuel simulation. The reviewer also observed that the research team would continue with the reduction of the more complex models into reduced models, which could be to shorten the computational time. This gives the modelers the latitude of choosing the appropriate model based on the needed fidelity and/or computational time. The reviewer commented that the work on soot modeling is also an important component of the team's activities.

Reviewer 3:

The reviewer advised that the research team continue to stay aware of current develops in commercial SAFs, as it would be great to have relevant mechanisms available as newer fuels develop.

Reviewer 4:

The reviewer stated that the research team did a great job ensuring that the next milestones are achieved successfully.

Reviewer 5:

The reviewer commented that the proposed future research work was too vague.

Reviewer 6:

The reviewer stated that the proposed work will continue to push this project toward significant outcomes and impacts. The plan to work to develop and deliver effective reduced kinetic models will benefit design simulations of new fuels and combustor designs.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer commented that this is clearly relevant and relates strongly to the DORMA goals, as the kinetic models are imperative for engineering of ICEs with LLCFs.

Reviewer 2:

The reviewer reiterated that this is important work, referencing their previous comments on the project.

Reviewer 3:

The reviewer stated that this is very useful work, being both detailed and with reduced mechanisms.

Reviewer 4:

The reviewer said that the project addresses the VTO goal of reducing GHG emissions from off-road HD by producing the kinetic models for developing the next generation engines.

Reviewer 5:

The reviewer commented that the project supports the overall VTO subprogram objectives for DORMA.

Reviewer 6:

The reviewer stated that the proposed work will continue to push the project toward significant outcomes and impacts. The plan to develop and deliver effective reduced kinetic models will benefit design simulations of new fuels and combustor designs.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that given the goals and the costs (which are mainly labor and computational costs), the resources and budget seem appropriate. The reviewer also noted that if additional experimental data or scope is pursued then the resources may be insufficient, but this could be mitigated by adding more direct tasks to other relevant DOE funded projects.

Reviewer 2:

The reviewer did not see any indication that the resources were insufficient.

Reviewer 3:

The reviewer stated that the resources appear to be fine.

Reviewer 4:

The reviewer noted that it is difficult to comment on project resources when DOE funding for such projects is very limited.

Reviewer 5:

The reviewer commented that the resources are sufficient for the FY 2022 and FY 2023 project milestones listed but will not be sufficient for the long-term project objectives beyond FY 2023.

Reviewer 6:

The reviewer stated that the funding level seems appropriate for such impactful work, given the scope.

Presentation Number: DORMA007
Presentation Title: Innovative NO_x Reduction Materials for Low Temperature Aftertreatment
Principal Investigator: Yong Wang (Pacific Northwest National Laboratory)

Presenter

Yong Wang, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

80% of reviewers felt that the project was relevant to current DOE objectives, 20% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 80% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 20% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

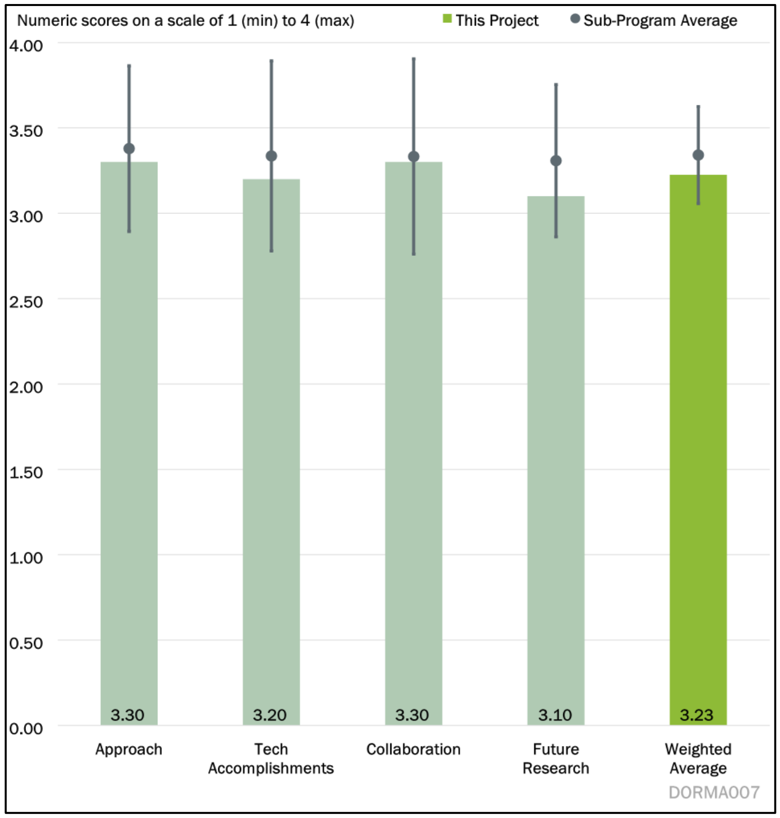

Figure 3-7 - Presentation Number: DORMA007 Presentation Title: Innovative NO_x Reduction Materials for Low Temperature Aftertreatment Principal Investigator: Yong Wang (Pacific Northwest National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer said that this team has addressed the barrier in cost-effective and sustainable NO_x emissions control. The project has been well designed, and the proposed work has been completed as scheduled. For example, the data in Slide 9 clearly show the storage of NO in the system.

Reviewer 2:

The reviewer stated that the approach has been excellent with appropriate tools used to study and characterize the catalyst. These include highly relevant theoretical density functional theory (DFT) studies as well as experimental work that is getting at the issues for this catalyst.

Reviewer 3:

The reviewer was confused as to this CRADA with Stellantis, who has no presence in the off-road market. The major problem with passive NO_x adsorbers (PNAs) is the repeated storage and release cycles that they are exposed to, which leads to capacity loss. The approach to this work does not include any repeated cycles, and without that, none of the results are going to be relevant to real world application. The reviewer stated that industry has essentially "stuck a fork in" this technology, so this project seems ill-advised.

Reviewer 4:

The reviewer commented that single-atom catalysts have been studied for a few years now and this study extends the field to a new specific catalyst formulation, so this is a well-focused study.

Reviewer 5:

The reviewer stated that the project is on track to the timeline, but key issues of poisoning and production are still required for future work.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer said that this team has demonstrated the storage of NO and its reduction by carbon monoxide (CO) with data shown in Slide 12. The data shown in Slide 11 demonstrated the super-low temperature performance of rhodium (Rh), ruthenium (Ru), and ceria over other candidates, which is the key achievement in this project.

Reviewer 2:

The reviewer stated that there has a been discovery in the project that Ru-ceria can have an excellent role as a PNA. This would be most useful in a diesel application if it was determined it was needed. The main benefit is the high NO_x to Ru ratio (as high as 14:1). The aging done in the project has always been for lean exhaust conditions and the lower temps in diesel exhaust make this a possibility durable formulation. The reviewer commented that the fact that Ru-ceria is a good NO-CO catalyst has been well-known for more than thirty years, but it has not been well studied, because ruthenium oxide (RuO_2) forms a toxic oxide. When it is heated, it is volatile enough to leave the catalyst under regular driving conditions, so OEMs have not chosen to use Ru. Many studies have shown it leaves the catalytic converter (e.g., SAE Paper #920846, 1992). However, the reviewer stated, there is a potentially different catalyst, a single-atom catalyst, whose durability has been examined by the usual aging conditions, but it would seem good for stoichiometric use to have its durability tested under rich-lean cycling conditions. In rich exhaust, Ru may turn metallic and form agglomerates and then perform more like typical catalyst preparations that volatilize at high temperatures. The reviewer suggested that be done, since if it durable under those conditions, it would be very interesting. For the equally interesting PNA system using Ru-ceria, this same testing is important in a more limited way, since it would be most likely used in remediating diesel exhaust in non-road emissions.

Reviewer 3:

The reviewer said that the approach to this project is missing work on the significant technical barrier for this technology.

Reviewer 4:

The reviewer stated that this is a good finding. Ru is shown to have a surprisingly high NO uptake for PNA applications. Highly stable (under hydrothermal aging) Ru/ceria catalysts are shown, though stability of the PNAs is a key bottleneck for application. The catalyst will also be about 20 times cheaper than state-of-the-art palladium (Pd)/zeolite catalysts. The reviewer commented that the results are well supported by DFT theoretical calculations.

Reviewer 5:

The reviewer remarked that the data showed that Ru/ceria-based PNAs can outperform traditional formulations. More discussion on where PNA technology can be used in industry would be helpful and how this new technology can help overcome PNA challenges such as performance in different use cases such as extended low-load operation and interaction with other species in the exhaust (water [H_2O], reducing gas species, poisoning agents such as sulfur).

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer remarked that Stellantis is an industry partner of this project. As indicated in Slide 14, Stellantis have provided/will provide aging, steady state, and Federal Test Procedure (FTP) dynamometer testing in the future. The reviewer is confident that Stellantis has provided input/guidance to this project as industry partner.

Reviewer 2:

The reviewer said that the way the project is moving, there must be good collaboration between these two strong teams. If the Ru-ceria catalyst is durable under high temperature cycling conditions, then a catalyst manufacturer would be a good addition to the team (presumably an interested supplier to Stellantis) that would build even further on this outstanding collaboration.

Reviewer 3:

The reviewer stated that collaboration with an on-road OEM for an off-road project seems to be an unusual choice.

Reviewer 4:

The reviewer noted that it is was mentioned that BASF Corporation (BASF) is involved which is great, though the team needs to take this research to a more practical level soon.

Reviewer 5:

The reviewer stated that there is good synergistic collaboration between the Pacific Northwest National Laboratory (PNNL) and Stellantis.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer said that the purpose of the future work has been clearly defined. As shown in Slide 16, the future work includes the slurry preparation, core sample, demonstration, and final evaluation.

Reviewer 2:

The reviewer commented that the future plan items look well thought out, although including ways to improve resistance to phosphorus poisoning is very difficult and of lower immediate pay off. However, if PNNL has a previous record of building P-resistance of their catalysts, then this would also be of interest. The reviewer said that, as mentioned above, the durability of the Ru-ceria catalyst should have durability testing under a wider range of conditions, including lean-rich cycling at relevant temperatures added to its list of future deliverables.

Reviewer 3:

The reviewer stated that PNAs are essentially a dead technology. Based on the approach taken in this project, they will not address the technical barriers to the technology, so future research is of questionable value.

Reviewer 4:

The reviewer said that in addition to phosphorus, it will be important to consider the effect of sulfur. It is not clear if the plan includes full size monolith coatings and engine testing. It will be important to test the new catalysts under practical conditions if this is to reach commercialization. The reviewer remarked that there is a need to address the challenge of Ru volatilization. Some challenges with respect to practical application were discussed—stability with two metals, high temperatures, etc. The project should investigate these factors.

Reviewer 5:

The reviewer stated that future work on poisoning and viability of large-scale production are the key issues. The reviewer further stated that they are looking forward to seeing this work.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer said that the project supports DORMA as aftertreatment is a key system in engine technology.

Reviewer 2:

The reviewer stated that this project has already found a new catalyst that could lead to a much lower cost for emissions control in the DORMA area. It presumably falls in a category (e.g., IV-10) of projects that make these kinds of improvements possible for diesel and non-road systems and stoichiometric systems.

Reviewer 3:

The reviewer stated that this project seems a bit lost and out of place in the portfolio.

Reviewer 4:

The reviewer said that upcoming regulations will require light-duty vehicles to comply with super-ultra-low emissions vehicle 30 (SULEV30) or tighter standards. Reducing platinum group metal use will be critical to doing so cost-effectively.

Reviewer 5:

The reviewer commented that any technology that can improve NO_x reductions and lower cost is of great interest to industry. The reviewer hoped that this project would continue.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that PNNL has extensive facility in catalyst preparation and sample evaluation. The engine test cell facility is available in Stellantis.

Reviewer 2:

The reviewer said that the resources available have, with good researchers, made excellent progress on the project.

Reviewer 3:

Given the tight funding in the VTO area, the reviewer commented that they are disappointed with this project. There are so many other areas that have been cut back, or entirely, that would make better use of this money.

Reviewer 4:

The reviewer stated that resources are sufficient for now but need to add engine testing.

Reviewer 5:

The reviewer said that the project seems to have adequate resources between PNNL and Stellantis.

Presentation Number: DORMA008
Presentation Title: Slashing Platinum Group Metal (PGM) in Catalytic Converters: An Atoms-to-Autos Approach
Principal Investigator: Kevin Gu (General Motors)

Presenter

Kevin Gu, General Motors

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

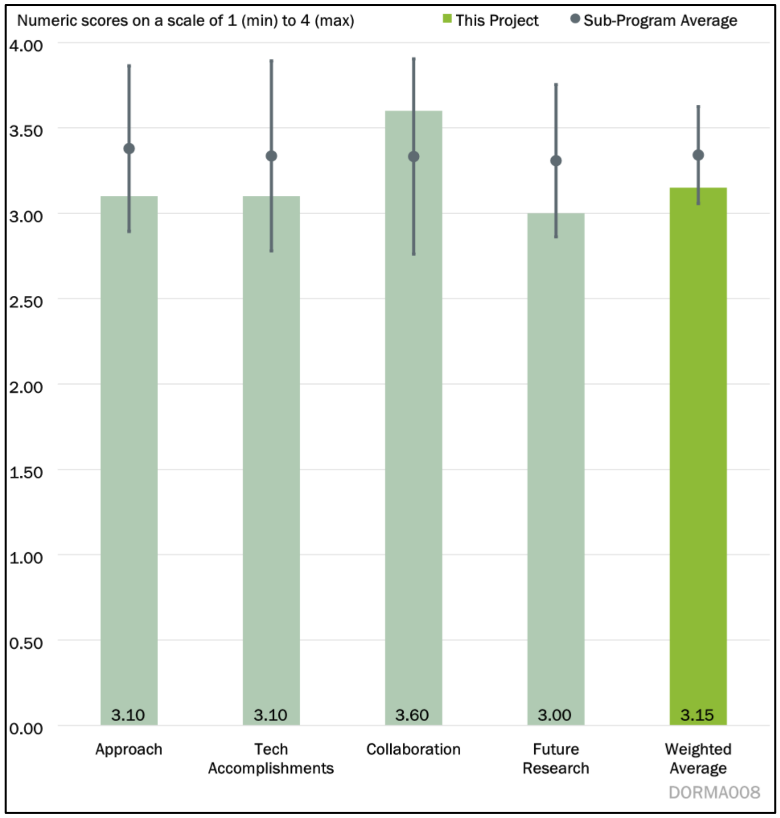

Figure 3-8 - Presentation Number: DORMA008 Presentation Title: Slashing Platinum Group Metal (PGM) in Catalytic Converters: An Atoms-to-Autos Approach Principal Investigator: Kevin Gu (General Motors)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer said that reducing platinum group metal (PGM) applications help to reduce the cost of three-way catalyst (TWC) in light-duty industry—a barrier in the auto-industry. The reviewer stated that the project was well planned but has been delayed due to foreign national (FN) participant approval. FN participant is super important for classified work but seems unnecessary for application work like DOE funded research. Unless specified by industry, the research data generated in DOE must be, or will be, made to public. The long process in FN check is delaying the progress of research in the U.S. and may put American industry in a difficult time in competing with other countries (e.g., from Europe, Japan).

Reviewer 2:

The reviewer stated that the approach has gotten some very interesting data of improved catalyst durability and activity. The reviewer also stated that they had heard somewhat more in the June 14 presentation than is captured in the slides submitted earlier that made clear that the preparation method using an intermediate metal oxide layer between the Rh or Pd catalyst material led to its ability to maintain small particle size and good activity using roughly 40% of the active catalyst material in the baseline commercial catalyst. Hence, the reviewer said, this approach is strongly supported.

Reviewer 3:

The reviewer stated that the atoms to autos approach seems ambitious—the idea of going to nearly atomic dispersion of PGMs to reduce PGM loading is wonderful in theory, but has many, many practical challenges, especially when it comes to poisoning and flaking. The reviewer said that the approach makes sense as a way to combat the sintering impacts of aging, as less total surface area loss occurs without big particles. However, there is not enough evidence that substantial activity is not lost over longer times, and this is only one part of the issue—mechanical failure (flaking of these fine catalyst layers) and poisoning are still large barriers to overcome.

Reviewer 4:

The reviewer said that the project has addressed the key barriers of making new catalysts with higher dispersion and stability, for potentially reduced PGM loadings. Experiments done using core and powder samples in laboratory conditions, but a key barrier of exploring performance under real-world engine conditions with full size parts is not addressed.

Reviewer 5:

The reviewer commented that there is a project start delay due to participant approvals.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer said that this team has made notable progress in catalyst preparation and characterization in laboratory at a delayed schedule. The time needed in transform powder and core samples to full size, fully formulated catalyst, and system demonstration on engine dynamometer or vehicle may take much longer time than planned.

Reviewer 2:

The reviewer commented that the accomplishments to obtain operational catalysts were done successively and successfully over a period of years to prepare durable, active catalysts. The details of the materials are not mentioned in the slides, since they are proprietary, so it is hard to comment in detail on what is new in this preparation, but it clearly improved the catalysts performance over baseline preparation methods. The reviewer stated that the goals so far appear to have been well met.

Reviewer 3:

The reviewer remarked that the technical accomplishments are generally good but have some weaknesses and may contribute to overcoming some barriers. The reviewer noted that while the team has demonstrated that they can in fact make these nearly atomic dispersion catalysts—and that there is some positive impact in the first round of synthetic gas testing—this is still quite a way off from demonstrating that this could lead to real reductions in PGM use and cost on the actual in-use devices. The reviewer rated this satisfactory not as a derogatory rating, but because it is “fine”—the progress is reasonable based on the timeline of the project and the budget period (BP) goals.

Reviewer 4:

The reviewer noted that the new catalysts are developed with improved dispersion and stability. The results for catalyst light-off under laboratory conditions and model gas composition show good promise with similar light-off at 60% reduced PGM. The reviewer commented that improvements in light-off are not clear since there are no numbers on the Y-axis. The catalysts are shown to lose dispersion after lean/rich aging. Some of this is irreversible depending on exposure time to lean/rich. This needs to be addressed.

Reviewer 5:

The reviewer commented that this was good progress, but the most important work is still ahead, confirming performance of aged catalysts via testing.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer said that this team presented extensive collaboration work with industry partners, as shown in Slide 17. Very strong support from partners is the key to success for this project. The reviewer also noted that GM has done an excellent job in coordinating the research in this project.

Reviewer 2:

The reviewer stated that the team assembled in this project is excellent, including excellent researchers from five institutions (GM, University of Central Florida, University of Virginia, PNNL, and BASF). The excellent results suggest excellent collaboration between these five research groups that come from universities, national laboratories, and industry.

Reviewer 3:

The reviewer noted that there are clear roles for all collaborators on the project.

Reviewer 4:

The reviewer said that collaboration is very good across the team. The reviewer also noted that it was good to see participation of academia and industry bringing in understanding at fundamental and applied levels.

Reviewer 5:

The reviewer remarked that the very strong team of OEMs, suppliers, national laboratory, and universities gives this project a high chance of success.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer commented that this team has clearly defied the purpose of future work. The future work can be achieved with the assumption that GM will put more resources, especially researcher time and facility, to this project. This is possible but challenging with the research and development work shifted from traditional engines to electric vehicles.

Reviewer 2:

The reviewer said that this project has had target dates extended for many deliverables for several reasons, including approval of foreign nationals. The project also started about the time of the beginning of the COVID-19 pandemic in the U.S. The project is 1 year from completion and its projected activities are important to get closer to possibly commercializing the improvements. For example, the reviewer noted, the Pd catalyst has been validated for its core performance and Rh needs to reach the same level.

Reviewer 3:

The reviewer commented that BP 3 has some incredibly ambitious goals—the idea of translating this very fundamental (to-date) study to actual devices to be put on vehicle and demonstrating performance on engines seems like a large hill to climb from where things are now. The transformation from powder and core samples to full sized bricks is difficult, so the reviewer was quite skeptical and wished the team much luck.

Reviewer 4:

The reviewer stated that the results need to be evaluated using full size catalysts and using engine testing, and it is good to see this in the plan. The reviewer also stated that the team needs to include chemical aging in the project plan. It is not quite clear how the deactivation under lean rich aging will be addressed. It will be good to demonstrate stability under a wide range of real-world operating conditions.

Reviewer 5:

The reviewer said that future work is critical, confirming the aged performance, overall cost savings, and potential for production.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer said that this project is closely relevant to DORMA. The reviewer also stated that it is the most relevant project of the six projects they reviewed this year.

Reviewer 2:

The reviewer commented that, more than many projects, this one clearly meets the goal of lowering the cost of emission control systems based on its ability to match baseline performance with 60% less catalyst material, which is important in the DORMA area.

Reviewer 3:

The reviewer said that this is relevant to VTO goals.

Reviewer 4:

The reviewer stated that reducing PGM is critical to enable improved emissions control at reduced cost.

Reviewer 5:

The reviewer commented that with unstable PGM prices, this is an important project. The reviewer highly recommended that the team continue this work.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented that the research has more hardware resources and facility than the delivery of this project. However, the reviewer suggested GM put more human research resources to this project as the work in the last year could be very challenging and needs more time and effort to get the work completed.

Reviewer 2:

The reviewer stated that over the past several years the researchers have made great strides finding a catalyst and have had the resources sufficient to meet their goals.

Reviewer 3:

The reviewer remarked that this is interesting fundamental research that is normally in the purview of Basic Energy Sciences (BES) or the catalyst suppliers and seems a bit out of place in the VTO portfolio.

Reviewer 4:

The reviewer commented that the resources look sufficient. It remains to be seen how much of the engine testing is done with a wide range of full-size catalysts.

Reviewer 5:

The reviewer stated that the team is strong and well-rounded.

Presentation Number: DORMA009
Presentation Title: NO_x Reduction with Low GHG Impact (N_2O Reduction for Off-road)
Principal Investigator: Feng Gao (Pacific Northwest National Laboratory)

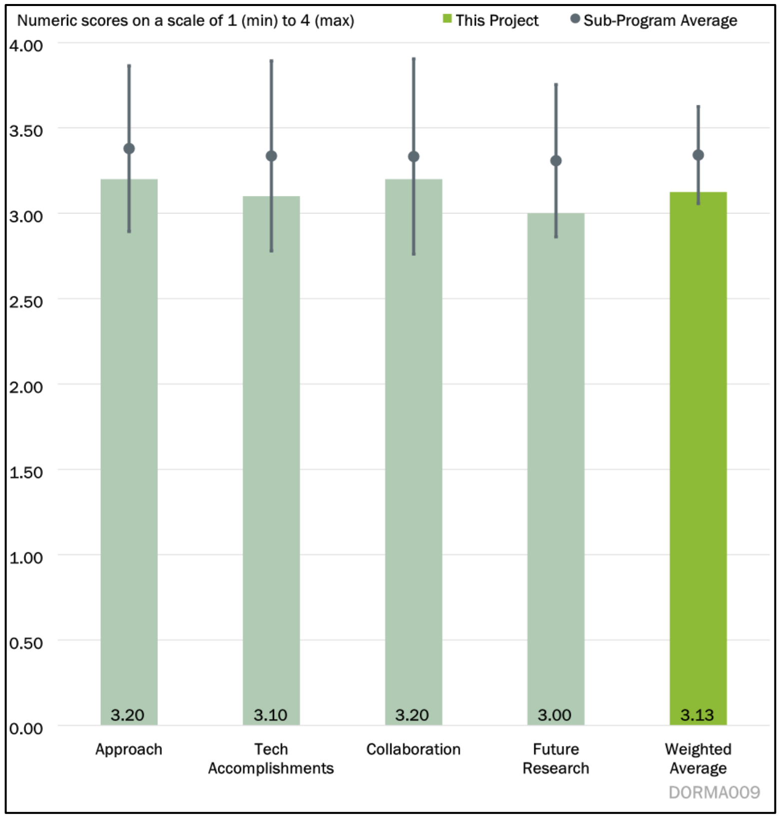

Figure 3-9 - Presentation Number: DORMA009 Presentation Title: NO_x Reduction with Low GHG Impact (N_2O Reduction for Off-road) Principal Investigator: Feng Gao (Pacific Northwest National Laboratory)

Presenter

Feng Gao, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 60% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 40% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

Nitrous oxide (N_2O) emissions gained increasing importance in the years past as regulations for GHG emissions were implemented. The reviewer found this project to have been well-designed. The timeline, as depicted in Slide 4, was well planned. Based on the reviewer's understanding of the time required to complete the remaining work, they were confident that the team could meet the established deadlines.

Reviewer 2:

The reviewer noted that the approach employed in this study to enhance NO removal without causing an increase in N_2O emissions, a potent GHG, was notably comprehensive, covering a wide range of issues related to using selective catalytic reduction (SCR) catalysts for NO_x control in off-road diesel vehicles. The exploration of various catalyst compositions and their impact on N_2O emissions, along with a focus on mechanistic issues, was highly commendable.

Reviewer 3:

The approach described primarily served as early-stage research for clarifying barriers (as seen in Slide 3) rather than directly addressing them. Therefore, the reviewer believed it might have been more suitable for funding by organizations like BES or the National Science Foundation (NSF), rather than DOE VTO. Given the tight financial constraints in this research area, it was somewhat surprising to encounter a project that appeared to fall outside the portfolio's scope. The project's objectives were relatively general, making it challenging to discern a clear connection between the ongoing work and these objectives.

Reviewer 4:

The reviewer stated that a fundamental understanding of N_2O formation was crucial, as it remained less comprehensively understood. Consequently, the study's emphasis on fundamental research across various practical catalysts was highly significant and addressed an essential need.

Reviewer 5:

While the project was commendable for its work on N_2O reduction and its substantial impact on global warming potential, the reviewer stated it could have benefited from additional efforts aimed at improving low-temperature activity, extending useful life, and reducing costs.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer observed that the team successfully completed the design of the catalyst and evaluated N_2O formation characteristics in December 2022. At that time, the team was engaged in characterizing the side requirements for N_2O formation through catalyst characterization. The reviewer noted that N_2O formation at low temperatures had been thoroughly examined, as evidenced by Slide 12.

Reviewer 2:

The reviewer recognized notable achievements within the project concerning the understanding of how N_2O formed on Cu-SCR catalysts. Specifically, it was observed that N_2O was generated from ammonium nitrate (NH_4NO_3) as one source and was promoted under conditions where NO_2 was produced during the reaction. The reviewer also noted the exploration of the role of Brønsted acid sites in this promotion. Furthermore, it was highlighted that high NO conversion catalysts could be a significant source of N_2O production. As far as this reviewer could discern, the strategy for simultaneously optimizing NO conversion while minimizing N_2O formation remained elusive. Consequently, achieving this balance would constitute a significant milestone for the project in addressing non-road NO_x and GHG emissions.

Reviewer 3:

As indicated in Slide 3, the reviewer understood that the primary goal of this work was to clarify, rather than solely overcome barriers. Thus, while this work might have helped overcome some barriers, it did not appear to be its primary focus.

Reviewer 4:

The reviewer noted that testing had been conducted with aged catalysts, including both hydrothermal and chemical aging. Overall, there had been commendable progress in enhancing the fundamental understanding of N_2O formation. The reviewer gleaned from the work that N_2O formation was a complex process that could not be attributed to a single step. It was likely that N_2O formation proceeded through nitrates, which could be formed either directly or indirectly, with or without NO_2 involvement. The outcome also appeared to depend on the type of SCR catalyst utilized (Cu, silicon/aluminum (Si/Al) ratio, etc.). The reviewer further appreciated the work's elucidation of how N_2O could form even in the absence of NO_2, as the latter could be formed *in situ* and directly through nitrates, bypassing the need for NO_2.

Reviewer 5:

The reviewer observed that, thus far, the work had placed a strong emphasis on N_2O reduction.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer found this project was supported by four industry partners and two universities. It appeared that the primary contribution of the industry partners was to provide valuable input regarding the research direction, as the majority, if not all, of the work was conducted at PNNL. Therefore, the reviewer recommended that the team specifically report on the contributions of each partner, with a particular emphasis on the industry partners.

Reviewer 2:

The reviewer stated the collaborators in this project included two companies that supplied engines for non-road vehicles, an active catalyst supplier, a zeolite manufacturer, Postech, and PNNL. These collaborators brought diverse backgrounds and strengths to the project, and there was strong interaction among them.

Reviewer 3:

While collaboration with John Deere, Cummins, Zeolyst, and BASF existed, the reviewer deemed the presentation did not provide a clear delineation of the specific roles of each participant and how coordination among them operated.

Reviewer 4:

The reviewer acknowledged the active participation of industry partners at various levels, encompassing equipment, engine, and catalyst manufacturers.

Reviewer 5:

The project had a strong team in place. However, the reviewer suggested that the team should place more focus on some of the other stated objectives, such as improving fuel utilization, reducing costs, and enhancing low-temperature performance. This would enhance the project’s overall effectiveness.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer stated that the project clearly defined the purpose of future work, as illustrated on Slide 17. The inclusion of theoretical calculations to enhance comprehension of NH_4NO_3 formation pathways in NH_3-SCR was deemed highly important and held significant promise for the advancement of SCR simulation, offering academia an opportunity to make substantial progress in SCR development.

Reviewer 2:

The reviewer remarked that there were specific research goals with evident utility. It was observed that proficient NO conversion catalysts often generated higher levels of N_2O, a phenomenon influenced by the roles of Brønsted acid sites and Cu loading. The proposal to investigate whether this applied to low carbon fuel vehicle emissions control was considered a promising direction. Furthermore, the reviewer suggested that taking a broader, system-level view could yield fruitful results and pave the way toward achieving this objective. The potential for utilizing machine learning to explore the extensive results for further research directions was also acknowledged.

Reviewer 3:

The reviewer commented on the proposed future work, stating that it seemed to align more with BES/NSF than with an applied office primarily focused on overcoming barriers. The outlined tasks, which included proposing pathways to mitigate or circumvent N_2O formation in NH_3-SCR, stabilizing NH_4NO_3 to facilitate the NH_4NO_3

+ NO reaction, balancing boron arsenide (Bas) and Cu density, and engaging in theoretical calculations to better understand NH_4NO_3 formation pathways in NH_3-SCR, were found to be better suited for such a context.

Reviewer 4:

The reviewer affirmed the importance of considering the trade-off between N_2O and NH_3 slip, suggesting that studying N_2O formation with varying ammonia-to-NO_x ratios could be beneficial. Although this might be perceived as beyond the project's initial scope, it was deemed a valuable avenue to explore. Additionally, the reviewer encouraged the inclusion of work with iron (Fe)-zeolite catalysts.

Reviewer 5:

In alignment with the previously mentioned objectives, the reviewer stressed the need for greater focus on enhancing low-temperature efficiency, improving FUL, reducing costs, and reducing N_2O emissions. These aspects were seen as pivotal in enhancing the overall success of the project.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer noted that this project played a crucial role in assisting the diesel engine industry in enhancing the performance of SCR systems, a critical aspect for next-generation diesel engines, particularly HD diesel engines.

Reviewer 2:

The reviewer observed that this set of project goals clearly aligned with the broader objective of identifying pathways to reduce the GHG emissions impact of emissions control systems.

Reviewer 3:

In general, the reviewer pointed out that the project's focus on catalyst material knowledge supported its goals. However, it was noted that this work appeared to be at a relatively low technology readiness level for VTO.

Reviewer 4:

The reviewer emphasized the importance of reducing N_2O, a potent GHG agent, and highlighted the significance of obtaining fundamental understanding to develop effective solutions.

Reviewer 5:

The reviewer stated that the project's objectives, including cost reduction, improving FUL, and enhancing low-temperature performance, were highly important and useful. However, it was noted that most of the project's efforts had concentrated on N_2O reduction. The reviewer suggested that addressing all the stated objectives would significantly enhance the project's overall impact and effectiveness.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer affirmed that PNNL possessed ample resources, including facilities, to support the project team in achieving the project's objectives.

Reviewer 2:

The reviewer acknowledged that the collaborators, particularly PNNL, brought substantial and well-suited resources to investigate the matter at hand.

Reviewer 3:

The reviewer expressed the view that this work could be categorized as "nice to have" rather than being a necessity for addressing barriers.

Reviewer 4:

While recognizing the presence of sufficient resources, the reviewer suggested that extending the scope to include Fe-zeolite or hybrid Fe-Cu systems would be highly beneficial.

Reviewer 5:

The reviewer praised the project for having a competent team in place and encouraged the pursuit of all the project's objectives.

Presentation Number: DORMA010
Presentation Title: Hardware in the Loop Toolkit for Off-Road and Marine
Principal Investigator: Muni Biruduganti (Argonne National Laboratory)

Presenter

Muni Biruduganti, Argonne National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 60% of reviewers felt that the resources were sufficient, 40% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

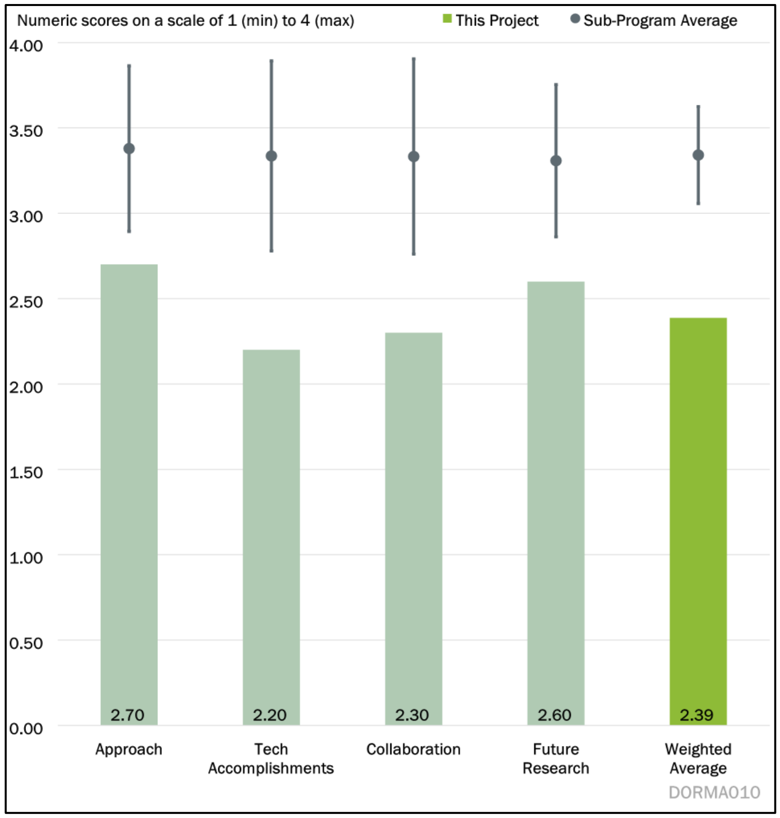

Figure 3-10 - Presentation Number: DORMA010 Presentation Title: Hardware in the Loop Toolkit for Off-Road and Marine Principal Investigator: Muni Biruduganti (Argonne National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer remarked that the project allowed Argonne National Laboratory (ANL) to develop a toolset already existing within the industry. Two industrial exemplars, AVL (https://www.avl.com/en/development-speed-and-methodology) and FEV Test Systems (https://www.fev-sts.com/testing-solutions/simulation-and-hil-solutions.html), were cited. While acknowledging the soundness of the approach, the reviewer pointed out the presence of commercially available hardware-in-the-loop (HIL) solutions, including real-time plant models capable of simulating engine testing on a dynamometer. The reviewer inquired about the unique contributions this project brings to the engine development community.

Reviewer 2:

The reviewer questioned whether it was necessary for these components to operate in real-time sync, as it is not a common practice in the commercial vehicle sector, and even less so in the marine sector. The reviewer suggested the need for a more comprehensive elaboration on the anticipated outcomes and benefits of the integrated approach. Additionally, concerns were raised regarding the project’s ambitious timeline to test a H_2 ICE in December 2023, just one month after its expected delivery. The reviewer sought clarification on any ongoing efforts to ensure the feasibility of this tight schedule.

Reviewer 3:

The reviewer praised the project as a valuable initiative providing real-world assessments for the use of low-emission engines in various off-road vehicle applications, encompassing a range of propulsion system types, from mechanical to hybrid configurations. The output of the project was emphasized as critical for evaluating potential impacts on GHG emissions and fuel consumption in future applications. The project's comprehensive approach, addressing both steady-state and transient aspects of mobility, was noted for its potential benefits in the development of low-emission engine subsystems. The reviewer, while acknowledging the project's challenges arising from its commencement during supply chain disruptions and shutdowns, questioned the project's timeline relative to its funding level and project type.

Reviewer 4:

The reviewer found the execution of the project to be lacking, even though the approach was considered acceptable. The primary approach was seen as using an existing HIL laboratory to verify off-road vehicles using a conventional diesel engine, with a transition to an H_2 ICE.

Reviewer 5:

The reviewer highlighted a significant weakness in the project, the absence of involvement from an industrial partner. The project was noted for lacking a defined engine platform for utilization, which was seen as a potential explanation for the limited progress achieved since October 1, 2021. Additionally, the reviewer questioned why the authors had not devised a backup plan for an H_2 test platform and mentioned potential distractions posed by the commissioning of a large diesel engine.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer noted that the team's progress was not satisfactory, given that they were halfway through the period of performance but had only completed 20% of the work. Delays in the delivery of the real-time controller from dSPACE and in the development of a production H_2 ICE from Cummins appeared to be the main factors for the slow progress.

Reviewer 2:

The reviewer observed that the infrastructure for H_2 fuel supply appeared to be set up and complete, although it was not clear what validation of this had been done. This aspect should be clarified. The demonstration of an off-road duty cycle with the Navistar engine was in progress, with a completion date expected by June 31, 2023. Powertrain models had been completed in Autonomie for off-road applications.

Reviewer 3:

The reviewer commended the principal investigators for being able to reconfigure their test facility for H_2 use and for being in a position to benchmark a legacy engine, recognizing these as critical steps toward reaching the ultimate goals of the project. However, the reviewer also noted that the project appeared to have progressed slowly and acknowledged that the timing of shutdowns and supply chain issues may have played a major role.

Reviewer 4:

The reviewer pointed out that the project was significantly behind schedule, likely due to personnel changes. Currently, the project was only 20% complete, and it should be closer to 50% complete. The reviewer expressed uncertainty about how the team planned to catch up.

Reviewer 5:

The reviewer emphasized the lack of technical information in the project. They noted that the team needed to promptly determine which H_2 ICE they would use and expedite their efforts to install it on the dynamometer.

The reviewer considered the effort reported on the H_2 infrastructure upgrades or on the transient dynamometer capabilities upgrades to be minor contributions, as these were standard capabilities in most engine laboratories. Furthermore, the reviewer pointed out that the authors had not discussed H_2-like operation approaches, such as the use of traditional spark ignition or stoichiometric three-way catalyst. The reviewer sought information on whether there was a plan to run homogeneous charge compression ignition-like operations, aiming at low heat losses and low NO_x emissions, and inquired about their anticipated efficiencies.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer commented it looks like ANL is the only member of the project team, which is unusual for a VTO-funded project. Dr. Biruduganti explained that there are two different ANL departments involved in this project. The two engine manufacturers identified in the project—Navistar and Cummins—are only weakly collaborating with ANL on the project.

Reviewer 2:

The reviewer stated the project is dependent upon collaboration with Cummins or other engine supplier. The success of the project is ultimately dependent upon this. Slide 16 further states that an un-calibrated Cummins H_2 ICE is needed. Calibration of the engine seems out of scope in this project. Is the intent that the project needs an open controller for this and has Cummins agreed with suppling such a controller with the engine.

Reviewer 3:

The reviewer was not clear as to the level of involvement of the two engine OEMs in this project. Nevertheless, they are supplying at least two engines of which one is a legacy product for HIL benchmarking while the other is an advanced low emission engine with the possibility of a third engines which will be an advanced low emissions engine. It is assumed the engine OEMs will ensure proper communication/controls are in place within the HIL and also will be involved in possible calibration change work as necessary.

Reviewer 4:

The reviewer commented the major task is to obtain a H_2 ICE from Cummins, but the reviewer did not see a commitment in writing that this is going to happen. It sounds like the engine is not available and will not be for some time. Not sure what the contingency plan is. The overall project needs more communication among the collaborators.

Reviewer 5:

The reviewer felt the team needs significant industrial support to move forward effectively.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer pointed out that there was uncertainty regarding whether the proposed Future Research outlined on Slide 17 was intended for this specific project or for broader, overall research initiatives. If intended for this project, the reviewer expressed concerns about its ambitious nature, particularly for a national laboratory, given the limited remaining time (18 months) and budget.

Reviewer 2:

The reviewer highlighted the project’s dependency on acquiring the appropriate H_2 ICE. They requested clarification on whether this engine needed to be calibrated, un-calibrated, or if the calibration could be modified.

Reviewer 3:

The reviewer stressed the significance of future work for the project's progress. They noted the industry's need for assessments of various propulsion system architectures, including power source evaluations and power transfer evaluations. The reviewer emphasized the central role of hybridization in these assessments and saw the HIL as a valuable resource for evaluating different propulsion system options. The reviewer anticipated that this future work would successfully meet its assessment targets, providing valuable propulsion system evaluations for off-road applications.

Reviewer 4:

While acknowledging the overall soundness of the research plan, the reviewer raised concerns about the project's ability to proceed in the absence of the required H_2 ICE.

Reviewer 5:

The reviewer expressed doubts about the project's ability to run an H_2 ICE and suggested that a significant change in approach was needed.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer emphasized that the project's primary objective is to examine H_2 ICEs as a means to address GHG emissions associated with traditional ICEs. Nevertheless, the reviewer pointed out the ongoing challenges related to NO_x and other criteria pollutants, underscoring that H_2 ICEs do not align with the California Air Resources Board's definition of zero-emission power units.

Reviewer 2:

The reviewer acknowledged the project's particular focus on the ability to operate HD off-road and marine H_2 engines, highlighting its alignment with the broader goals of the VTO programs.

Reviewer 3:

From the reviewer's perspective, the project strongly supports the objectives laid out by DOE's VTO programs. The project holds the potential to serve as a valuable experimental and modeling/simulation tool aimed at reducing emissions in future off-road applications. Moreover, it is poised to enhance fuel consumption characteristics through the incorporation of advanced low heat rejection engines and advanced propulsion systems, potentially involving various levels of hybridization and electrification. The reviewer stressed the pivotal role of the project's experimental component and the need for heightened attention to this aspect in the coming year.

Reviewer 4:

The development of more efficient H_2-powered off-road vehicles aligns with the overarching objectives of the VTO program.

Reviewer 5:

The reviewer contended that the project represents a potential pathway towards achieving decarbonization in off-road applications through the use of ICE.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer noted that the ANL team had most of the necessary components at the project's outset, including the Navistar engine and the foundational models in Autonomie, indicating that they possess the required resources to complete the project. However, the primary challenge faced by the ANL team appears to be time constraints.

Reviewer 2:

The reviewer did not express any particular concerns but suggested considering the engine sizes that are targeted and needed for the project. The project's scope involves both a 6.7 L and a 15 L engine, and it should be noted that doubling the engine displacement would likely increase the overall cost of operation.

Reviewer 3:

The reviewer found the project's funding to be somewhat insufficient relative to the level of effort and facility upgrades required to conduct this experimental work. The project entailed infrastructure upgrades, extensive testing hours, and significant post-processing and interpretation of results. The allocated budget of $1.2 million was considered somewhat low for this type of effort.

Reviewer 4:

The reviewer noted that if the project team were on schedule, the funds would likely be adequate. However, given the current 20% completion status, it was suggested that the budget would only have been 20% spent at this point.

Reviewer 5:

The project was identified as in need of an industrial partner to provide guidance, particularly in terms of validating the engine platform or directing the retrofitting of existing engines to run on H_2. The reviewer indicated that the current team did not appear to possess the necessary technical capabilities and resources to accomplish these objectives.

Presentation Number: DORMA012
Presentation Title: H2 Combustion Research - CRADA with Wabtec
Principal Investigator: Muhsin Ameen (Argonne National Laboratory)

Presenter

Muhsin Ameen, Argonne National Laboratory

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

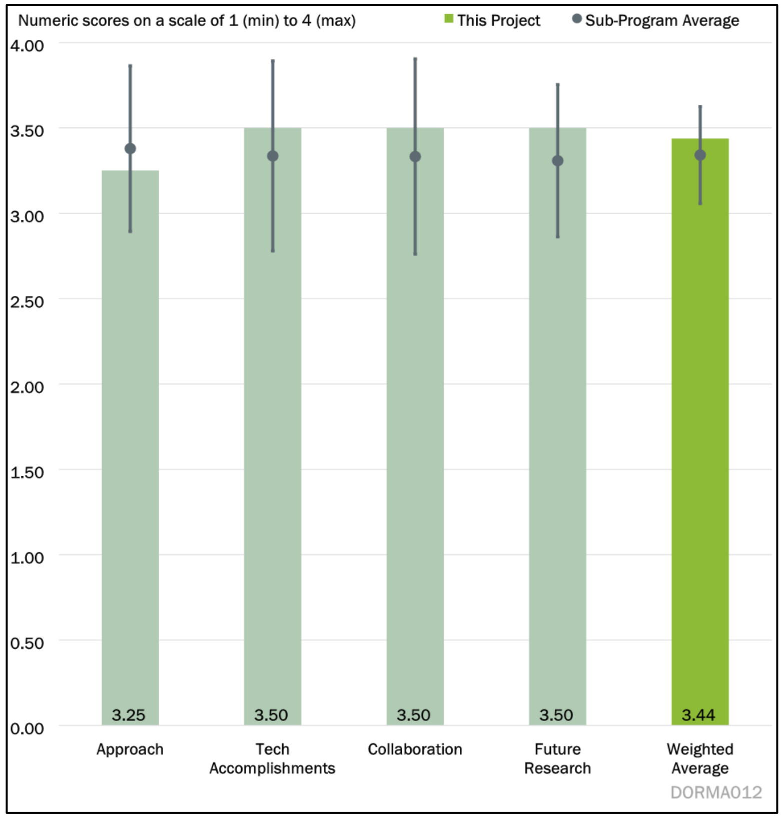

Figure 3-11 - Presentation Number: DORMA012 Presentation Title: H2 Combustion Research - CRADA with Wabtec Principal Investigator: Muhsin Ameen (Argonne National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer comprehended that the project encompasses both traditional dual fuel and high-pressure direct injection (HPDI) approaches. The reviewer expressed concern that these two combustion approaches are considerably different and might pose a challenge to address simultaneously. The reviewer indicated a preference for selecting one approach, particularly favoring HPDI due to its potential for achieving high substitution rates.

Reviewer 2:

The timeline was deemed reasonable, with the reviewer emphasizing that the key to making progress would involve support from Oak Ridge National Laboratory (ORNL) and successfully getting the single-cylinder engine up and running, first using diesel and then transitioning to dual-fuel with H_2. The reviewer also noted that the Approach slide highlighted support for H_2 engine development, starting with port injection and aiming for a 90% substitution goal with direct injection. The reviewer inquired about the presence of direct injection work in the current plan and whether it was reserved for FY 2024 efforts. The reviewer assumed that the ORNL engine test would also be a parallel effort with direct injection in the test engine and pointed out the absence of any mention of spark plugs in the project’s scope.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer, while not a modeling expert, found the project's approach to be reasonable.

Reviewer 2:

The reviewer saw the team as making a good start, particularly in terms of validating the model with diesel and natural gas dual-fuel engine data.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer also noted a strong alignment between the team members' backgrounds.

Reviewer 2:

The reviewer acknowledged that the team appeared to be making progress but anticipated potential challenges in this area. The reviewer reiterated that the key to success would be timely data input and parallel progress from ORNL.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer believed that the modeling aspect had a good potential to assist in transitioning to test cell operation of the single-cylinder research engine.

Reviewer 2:

The transition to direct injection with a 90% substitution and reaching 100% with spark ignition was highlighted as an essential step. The reviewer pointed out that NO_x predictions would be crucial for both the port injection and direct injection studies.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer recognized that the project aligned with several objectives but did not encompass all aspects, such as materials, batteries, and electrification.

Reviewer 2:

The reviewer emphasized the importance of H_2 internal combustion engines (H_2 ICEs) as a pathway for exploring decarbonization in the rail industry.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer noted that the team had made a good start and appeared to have a plan for completing the project. However, the reviewer expressed a limitation in fully assessing the team's ability to meet milestones without attending their weekly meetings.

Reviewer 2:

The reviewer found the funding through FY 2023 to be reasonable but requested more details regarding funding for FY 2024–FY 2026 to provide an overall assessment of project funding.

Presentation Number: DORMA013
Presentation Title: Experimental and Numerical Research on Biodiesel and Renewable Diesel Blends for Locomotive Engines
Principal Investigator: Chao Xu (Argonne National Laboratory)

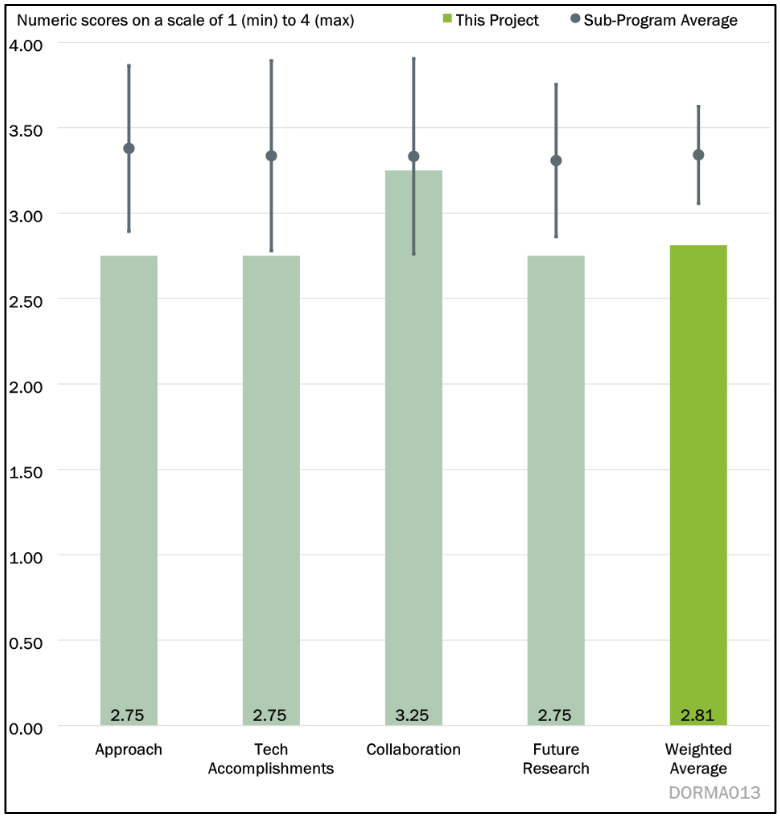

Figure 3-12 - Presentation Number: DORMA013 Presentation Title: Experimental and Numerical Research on Biodiesel and Renewable Diesel Blends for Locomotive Engines Principal Investigator: Chao Xu (Argonne National Laboratory)

Presenter

Chao Xu, Argonne National Laboratory

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer found the project's approach reasonable but expressed concerns about the timeline, considering it to be too long.

Reviewer 2:

The "Barriers and Technical Targets" slide raised questions for the reviewer regarding the inclusion of reliability, as it was not evident in the project's scope. The reviewer acknowledged that understanding engine performance and emissions was essential before delving into field reliability testing.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer questioned the extended timeframe for obtaining engine data with different fuel blends, given that the single-cylinder research engine (SCRE) was already installed at Argonne National Laboratory. The reviewer also sought clarification on the prolonged duration for modeling work, considering that the engine already existed and there should have been accurate models in place for designing the original engine's fuel system. The project's alignment with liquid fuels further raised questions regarding the need for an extended timeline.

Reviewer 2:

The milestone chart was commended for reflecting good progress, particularly in getting the SCRE up and running, conducting baseline diesel CFD analysis on the injector, and developing the engine model.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer did not identify any issues in the provided presentation.

Reviewer 2:

The reviewer noted that the team appeared to be making progress with the support of various organizations, including Progress Rail, Chevron Renewable Energy Group, and Convergent, as well as coordination with the Federal Railroad Administration and DOE.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer expressed a degree of skepticism about the project's timeline and its potential to provide industry-advancing insights due to the existing field tests with similar fuels.

Reviewer 2:

The reviewer anticipated that future research focus would likely emerge from the findings of the current work and underscored the importance of validating models with various biofuel blends tied back to engine data.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

While the project was viewed as relevant to DORMA, the reviewer believed it should have been completed over 2 years ago.

Reviewer 2:

The reviewer commented that biofuels were recognized as a crucial technology in the context of rail decarbonization, especially considering the extended timeframes for H_2 and battery options in the rail sector.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

In terms of resources, the reviewer deemed the project sufficiently resourced, primarily because the SCRE was already installed, and Argonne National Laboratory had access to the OEM's existing models.

Reviewer 2:

The reviewer described the funding as "barely sufficient" noting the challenges associated with conducting laboratory work on locomotive engines, which are heavy and expensive.

Presentation Number: DORMA014
Presentation Title: Implementing low lifecycle carbon fuels on locomotive engines – CRADA with Wabtec
Principal Investigator: Dean Edwards (Oak Ridge National Laboratory)

Presenter

Dean Edwards, Oak Ridge National Laboratory

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

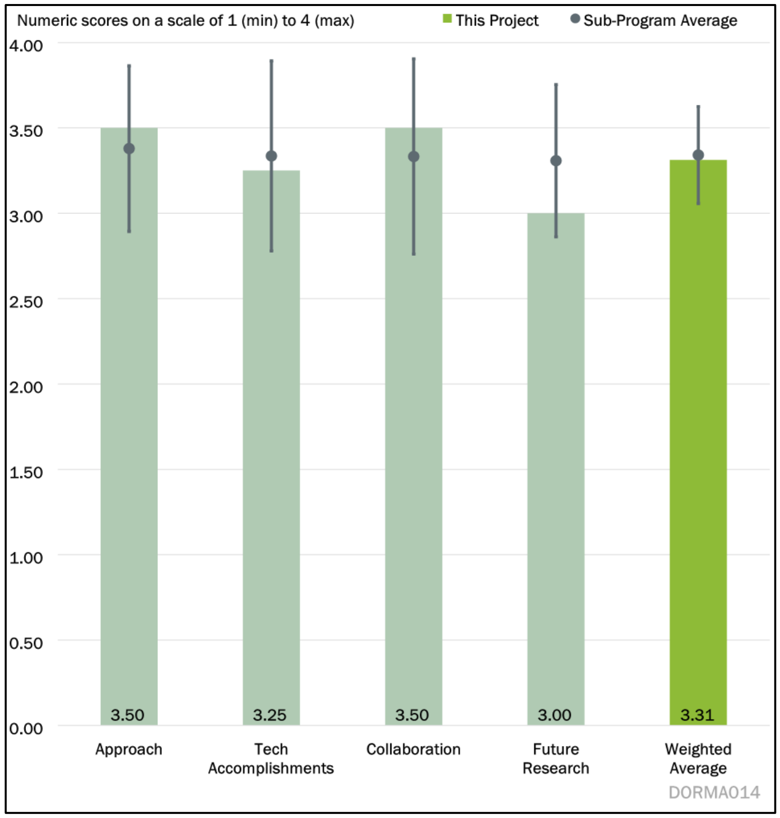

Figure 3-13 - Presentation Number: DORMA014 Presentation Title: Implementing low lifecycle carbon fuels on locomotive engines – CRADA with Wabtec Principal Investigator: Dean Edwards (Oak Ridge National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer highlighted the potential of the single cylinder engine (SCE) as a valuable resource for validating models without the complexities associated with operating a multi-cylinder engine. However, the reviewer expressed concerns about the time and cost required for installing the necessary infrastructure, as well as the significant challenges involved in setting up and maintaining the safety systems for the test cell.

Reviewer 2:

The project was seen as a crucial endeavor requiring a substantial amount of research and development work to develop H_2 ICEs for locomotive engines. The reviewer believed the project had the essential components to make a strong start in this regard.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The progress achieved thus far was considered reasonable, but the reviewer anticipated potential issues in obtaining approvals to operate the test cell. The reviewer emphasized the need for extensive upfront work to facilitate the transition from an infrastructure upgrade and SCRE installation project to the operational phase.

Reviewer 2:

Given the project's status approximately 1 year in, the 18% completion figure was seen as appropriate by the reviewer.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer acknowledged that the team appeared to be working cohesively, which was viewed as a significant factor in enhancing the project's likelihood of success.

Reviewer 2:

The project received good support from Wabtec, along with the Oak Ridge National Laboratory team. However, there was limited discussion in the slides about ANL and Convergent CFD status, support, and collaboration. The reviewer suggested that including information about the funding allocation and effort distribution between ANL and Convergent in future briefings would be beneficial.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer stated that the outlook for the project was expected to brighten significantly once the test cell was commissioned and the SCRE became operational.

Reviewer 2:

The reviewer noted that the presentation lacked specific details beyond achieving 50% H_2 substitution with port injection. This emphasis on facilities-related matters was deemed understandable given the project's current focus. Future research aspects, as highlighted on Slide 10, included compression ratio, dilution (presumably related to turbocharger simulation), and EGR. The reviewer recognized the need to "turn all those knobs" to optimize the system, although it was acknowledged that maintaining 100% diesel capability would be a challenge. The direct injection work was characterized as somewhat of a fresh start but considered worthwhile to maximize substitution.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer stated that the project was categorized under DORMA.

Reviewer 2:

The reviewer noted that H_2 ICE could be a crucial bridge technology for decarbonization in long-life locomotives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer emphasized that only time would determine whether the level of effort and funding was adequate. Having the engine OEM available and an active team member was seen as factors that could reduce the likelihood of the SCRE becoming a bottleneck in achieving the project's milestones.

Reviewer 2:

Regarding funding, the reviewer considered it to be robust, which was deemed necessary for the work involved. The budget, as presented in Slide 2, was presumed to be linear. However, the reviewer pointed out that expenses would escalate rapidly as the team began purchasing expensive H_2 and conducting extensive engine operating hours with high substitution rates. Additionally, the cost of operating the facility was anticipated to be significant, with the electricity bill for the turbocharger simulation system noted as a potential source of high expenses.

Presentation Number: DORMA015
Presentation Title: Enabling H_2 and Methanol Combustion
Principal Investigator: Riccardo Scarcelli (Argonne National Laboratory)

Presenter

Riccardo Scarcelli, Argonne National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

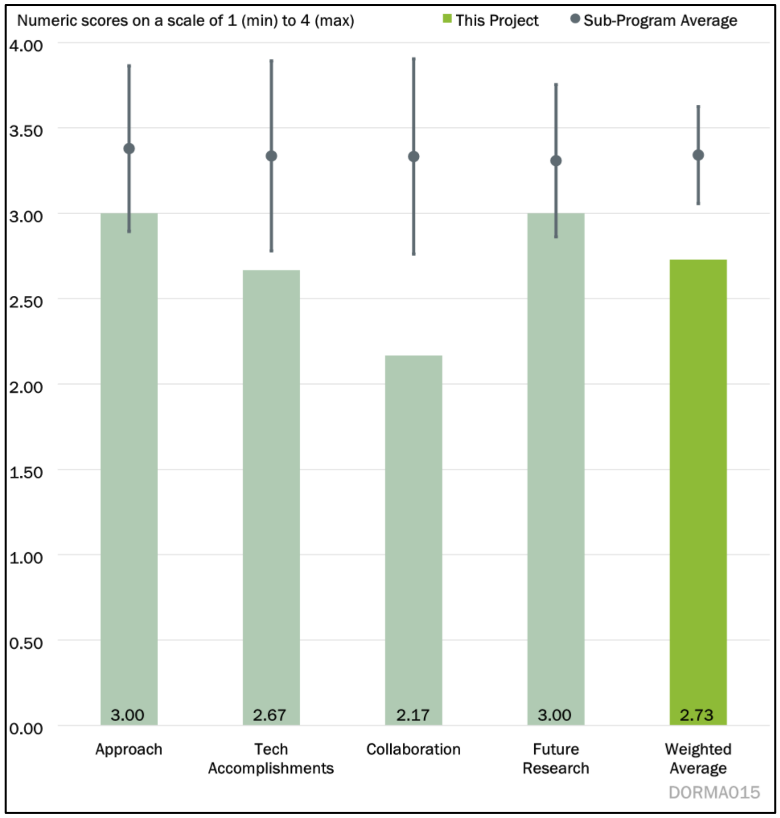

Figure 3-14 - Presentation Number: DORMA015 Presentation Title: Enabling H_2 and Methanol Combustion Principal Investigator: Riccardo Scarcelli (Argonne National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer expressed uncertainty about why the H_2 work would commence first, speculating that it might be because existing models were available and that lessons learned from other methanol projects would be applied when the methanol (MeOH) work began. The two project objectives appeared somewhat disconnected, lacking clear linkages between the H_2 and methanol components. The reviewer pointed out that many methanol engines were currently being designed and produced, and the delay in starting this aspect of the project for 2 years was considered a missed opportunity. The suggestion was made to work on the tasks related to H_2 and methanol in parallel.

Reviewer 2:

The reviewer noted that the project could not be fully initiated due to the unexpected loss of some partners, and the rating of “satisfactory” was considered a placeholder. Overall, the adoption of low-carbon fuels was viewed as a valid approach to decarbonization throughout the product’s life cycle. The reviewer recommended providing a one-to-two-page summary that supports the remaining barriers and unknowns, particularly in light of the extensive literature and prior work on the combustion of methanol and H_2 in engines. The availability of low-carbon H_2 and methanol should also be discussed.

Reviewer 3:

The project plan was commended by the reviewer for addressing technical barriers and being well designed and planned.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer expressed uncertainty about how to evaluate the project since it had not yet started. A “satisfactory” rating was given, with the hope that this score would not be included in the overall project rating.

Reviewer 2:

The reviewer noted that the project could not be effectively evaluated at this stage, and the “fair” rating was considered a placeholder. The reviewer suggested that a “not applicable” rating might be more appropriate.

Reviewer 3:

Despite the project not having started, the reviewer acknowledged that it was well planned.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer noted the difficulty in evaluating the project since it had not yet commenced, and project team members were not publicly known. A “satisfactory” rating was assigned, with the hope that this score would not be factored into the overall project rating.

Reviewer 2:

The reviewer highlighted that the project was unable to proceed due to the loss of a partner.

Reviewer 3:

Despite the inability to disclose all project collaborators publicly, the reviewer acknowledged that the level of collaboration appeared to position the project for success.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer expressed a desire to see a Diversity, Equity, and Inclusion (DEI) SMART milestone included in the project’s scope. Additionally, the reviewer reiterated the importance of reconsidering the project’s task sequence, specifically in terms of advancing the timing for MeOH work. This adjustment was seen as beneficial for the industry, given the current focus on MeOH over H_2 ICEs.

Reviewer 2:

The reviewer recommended revisiting the project once partnerships were re-established, indicating that the absence of key partnerships had impacted the project’s evaluation.

Reviewer 3:

The reviewer commented that as the project had not yet begun, future work had not been extensively addressed at this stage.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer agreed with the relevance of the project.

Reviewer 2:

The reviewer affirmed that the successful deployment of net-low carbon fuels is a viable approach to carbon reduction. The reviewer suggested that the project should focus on addressing key barriers and inquired whether there had been a workshop involving engine and fuel stakeholders.

Reviewer 3:

The reviewer noted that the project was considered relevant to the broader VTO program objectives, particularly within the scope of DORMA.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer indicated that it was challenging to assess the project fully, primarily due to the inability to disclose project team members. However, the current suite of models and planned models were considered highly relevant.

Reviewer 2:

The reviewer recommended revisiting the budget in light of the inclusion of new partners.

Reviewer 3:

The reviewer stated that the budget was adequate to support the project in achieving its milestones.

Presentation Number: DORMA016
Presentation Title: Renewable methanol-fueled engines for marine and off-road applications
Principal Investigator: Jim Szybist (Oak Ridge National Laboratory)

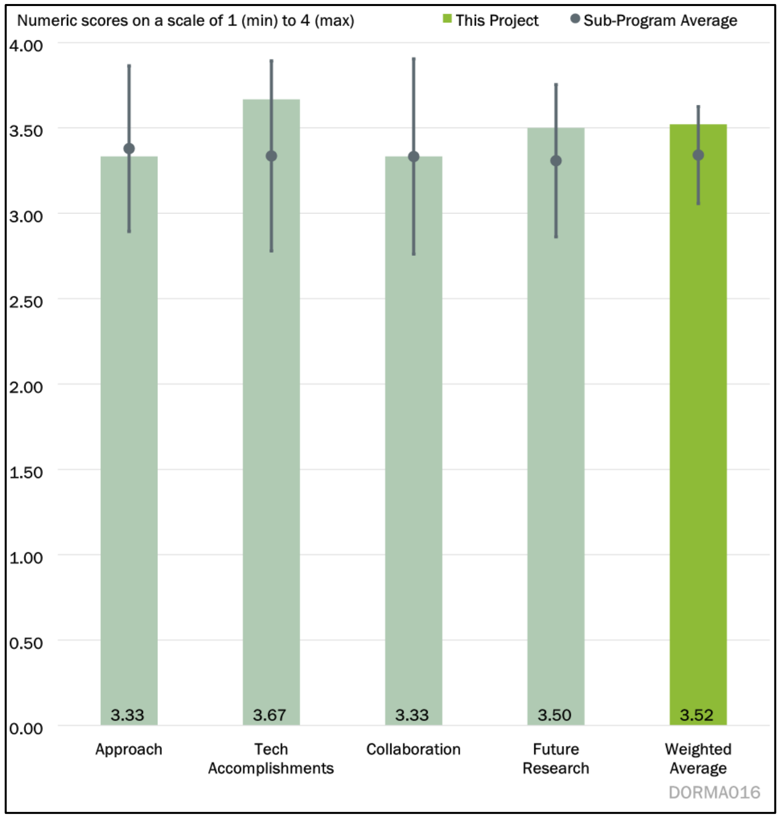

Figure 3-15 - Presentation Number: DORMA016 Presentation Title: Renewable methanol-fueled engines for marine and off-road applications Principal Investigator: Jim Szybist (Oak Ridge National Laboratory)

Presenter

Jim Szybist, Oak Ridge National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer appreciated that the technical barriers were presented and discussed in the project. The three different ignition types being investigated were viewed positively. However, the reviewer raised the following points for consideration: catalyst lifespan/poisoning; water handling; methanol quality; and state of industry assessment. Regarding catalyst lifespan/poisoning, the reviewer inquired if catalyst lifespan and potential catalyst poisoning would be investigated. Concerning water handling, it was unclear to this reviewer how the water produced during the reforming process with zeolite would be stored onboard and managed. Separation of water from the produced H_2 could be an important aspect, and optimization of this separation process would be interesting. Thew reviewer suggested more investigation into the quality of methanol, particularly in relation to new green methanol production pathways (e.g., bio-methanol, e-methanol) as opposed to commodity methanol. This data could be valuable in scenarios where lower-quality green methanol might be a more cost-effective option. Finally, the reviewer noted the project team was encouraged to conduct a state-of-industry assessment to ensure that their data could be utilized or compared with other engine types in the marine engine sector, such as those produced by MAN Energy Solutions, ABC-Engines, Daihatsu, and Wartsila.

Reviewer 2:

The project's three-pronged approach to investigating methanol combustion was commended, along with the successful pivot and leverage of previous prechamber spark ignition work. The modification of the diesel platform to accommodate both methanol and dimethyl ether was also viewed positively.

Reviewer 3:

Overall, the reviewer found that the project effectively addressed technical barriers, was well designed, and had a reasonably planned timeline. The delay in the installation of the intake manifold modifications on the prechamber engine was not seen as a significant challenge to project completion within the planned timeline.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer commended the project's substantial progress made within the first six months of work. Despite missing the Q2 milestone, the project was noted to be on track to meet the Q4 milestone.

Reviewer 2:

The reviewer pointed out that significant advancements had been achieved in both the single-cylinder and multi-cylinder engine modification aspects of the project.

Reviewer 3:

Overall, the reviewer observed solid progress relative to the project plan, with full awareness of the remaining challenges.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer acknowledged that it was still early in the project's development but noted that the team appeared to be working effectively with project partners, particularly Caterpillar, in the area of engine design.

Reviewer 2:

The reviewer also highlighted the presence of clear roles and responsibilities for all project partners, which was seen as a positive aspect of the project's organization.

Reviewer 3:

Overall, the reviewer commended the project team for demonstrating a high level of collaboration, with a particular emphasis on the valuable collaboration with Caterpillar.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer acknowledged that the project had a well-structured plan with many valuable components. The reviewer suggested that some additional areas, alluded to in the first question, could further strengthen the planned work. This included a tank-to-wheel/wake life-cycle assessment comparison of the three different combustion scenarios, as well as the inclusion of a project-specific DEI SMART milestone, rather than relying solely on the national laboratory's DEI plan. The suggestion of engaging project interns and creating an outreach program for underserved high schools was also made.

Reviewer 2:

The reviewer appreciated that the remaining barriers were clearly defined and noted that there was a detailed plan in place for accomplishing seven tasks over a 4-year period, involving three engine platforms and bench flow reactor experiments.

Reviewer 3:

The reviewer felt the project's detailed plan for future tasks was setting it up for successful contributions.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer indicated agreement with the project's relevance to all current and potential stakeholders and how it aligns with the multi-agency blueprint on decarbonizing hard-to-electrify sectors.

Reviewer 2:

The project was considered relevant to the interests of the VTO by the reviewer.

Reviewer 3:

The reviewer stated that project was supportive of overall VTO subprogram objectives, particularly within the scope of DORMA.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer found that the project's resources were aligned with its scope.

Reviewer 2:

The project was viewed by the reviewer as being aligned with the goal of de-fossilization, which is important for both DOE and the U.S. Department of Transportation. Investing in renewable and sustainable liquid fuels was seen as a key objective.

Reviewer 3:

The budget for FY 2023 and beyond was considered sufficient by the reviewer to support the achievement of the project milestones.

Presentation Number: DORMA017
Presentation Title: SAF End Use Research
Principal Investigator: Sibendu Som (Argonne National Laboratory)

Presenter

Sibendu Som, Argonne National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 25% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

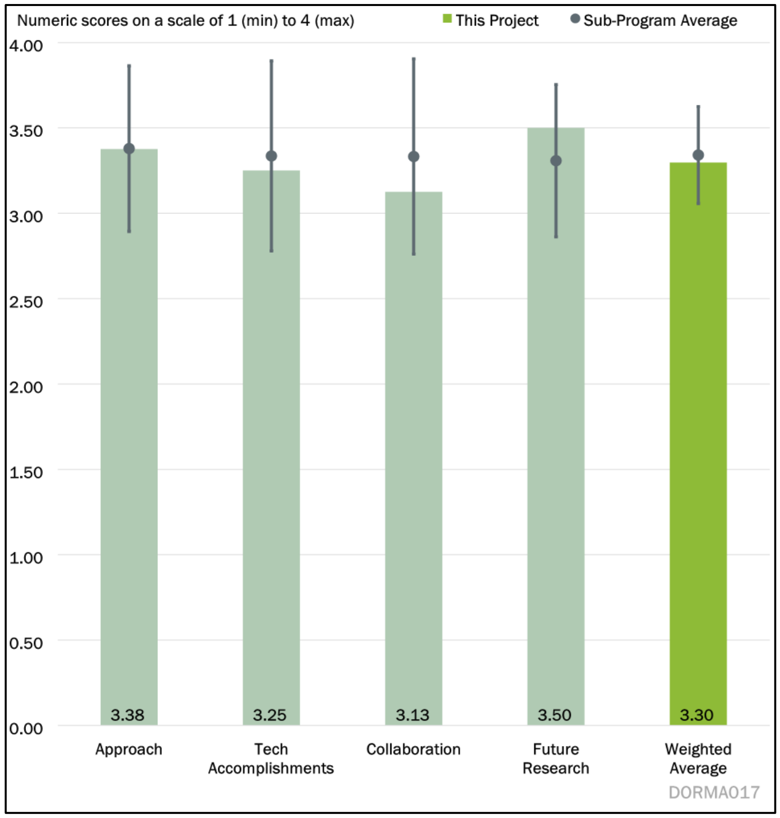

Figure 3-16 - Presentation Number: DORMA017 Presentation Title: SAF End Use Research Principal Investigator: Sibendu Som (Argonne National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer praised the project for addressing the right technical barriers and noted that the presentation provided a comprehensive list of technical barriers in the roadmap. However, the reviewer suggested the inclusion of a master timeline that highlights the interdependencies of various project components.

Reviewer 2:

The timeline for the project was considered reasonable, and the study was seen as addressing important technical challenges associated with fuel property variations, fuel characterizations, chemical kinetics modeling, and data generation. The reviewer emphasized the importance of model validations with real systems, engagement with OEMs, and post-test refinement of models and mechanisms using relevant engine combustion and field data.

Reviewer 3:

The reviewer indicated that their rating considered the combined impact of multiple DORMA projects, covering a wide range of topics related to sustainable aviation fuels and their usage. The reviewer also highlighted the clear linkage between these projects and the SAF Grand Challenge goals, as well as their relevance to increasing SAF usage, particularly in addressing issues related to contrails.

Reviewer 4:

The reviewer commented that overall, the presentation was viewed as a good overview of DOE program on SAFs.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer noted that the presentation teed up several sub-projects. The principal investigator presentations were effective in demonstrating the technical progress of each component of the plan. However, the presenter could have provided a quick indication of the progress of each project, highlighting areas with significant learnings and those with open questions and challenges to address.

Reviewer 2:

The reviewer observed significant progress in critical property characterization, soot kinetics, soot models, and ice nucleation models, as well as initial fuel spray characterization studies. The modeling activity appeared to have progressed at an impressive pace. However, the reviewer found that the progress of the experimental spray and turbine combustion studies at relevant engine conditions depended on a larger vision yet to be set by DOE and Argonne National Laboratory and/or communicated to the reviewers. There was a lack of clarity on the clear path forward and the timeline for either an infrastructure build within Argonne to support this plan or identifying a non-Argonne capability.

Reviewer 3:

In their rating, the reviewer considered the combined impact of the following DORMA projects: 03, 17, 18, 19, 20, 37, and 38. This set of projects, in the reviewer’s assessment, had made excellent progress in terms of testing conducted, models developed, simulations performed, and processing of experimental data across a wide range of processes crucial to understanding and utilizing sustainable aviation in aircraft engines.

Reviewer 4:

The reviewer clarified that their evaluation was more of an assessment of the overall program rather than focusing solely on the specific presentation. In their view, the overall program was making substantial progress, particularly in the computational modeling of SAF combustion processes.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer observed that the presenter effectively portrayed the various projects and their integration into the larger framework. The reviewer also commended the presenter for outlining the involvement of various laboratories and illustrating coordination among industry, government, and academia. However, the reviewer noted the absence of identification of academic partners and collaborators.

Reviewer 2:

The reviewer highlighted the necessity for a clearer definition of OEM participation. They questioned the level of coordination in combustion modeling activities, specifically in terms of knowledge and data sharing between Argonne and the National Renewable Energy Laboratory. Additionally, the reviewer expressed a desire to see more utilization of the Air Force Research Laboratory’s legacy work and closer collaboration.

Reviewer 3:

In the reviewer’s rating, they considered the combined impact of the following DORMA projects: 03, 17, 18, 19, 20, 37, and 38. The reviewer acknowledged a wide range of collaborations within DOE and with external partners. The reviewer suggested improving the coordination of CFD efforts within DORMA 037, 038, and 003. They raised concerns about potential overlap in simulated cases and the absence of simulations for the same geometry/condition with consistent fuel properties and chemistry models between these projects, particularly DORMA 037 and 038.

Reviewer 4:

The reviewer commended the collaboration and coordination within the overall program, noting effective cooperation among its different components. However, the reviewer expressed disappointment regarding the limited participation of academia, acknowledging that this perspective may be influenced by their academic background.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer found that the proposed future work aligns with the current needs. The presenter appropriately recognized the imperative of addressing end-use issues related to drop-in fuels, a major obstacle to the widespread use of SAFs. The reviewer commended the presenter for assembling an excellent roadmap addressing this critical concern. Acknowledging the inherent risks associated with combustion testing, the reviewer acknowledged that it might be challenging for this project to achieve all of its targets but emphasized that the roadmap is correctly oriented toward essential research.

Reviewer 2:

The reviewer identified certain hurdles that must be overcome, including effectively navigating the participation of OEMs, generating pertinent data at conditions meaningful for model validations, and successfully implementing such models within the OEM community to demonstrate their impact.

Reviewer 3:

The reviewer highlighted that all projects commenced in FY 2022 and are assumed to extend through FY 2027, contingent on funding. The presentations provide summaries of the work accomplished up to this point and typically outline the plans for FY 2024 or, at times, describe it as “future work” without specifying a timeline. While the purpose of the future work is evident, the reviewer noted that the actual work planned beyond FY 2024 is generally not clearly stated.

Reviewer 4:

The reviewer noted that the future research proposed by various team members addresses issues related to the use of SAFs for aircraft propulsion. The proposed work in computational simulation of SAF sprays and combustion leverages the unique capabilities of DOE, aligning with the specific expertise and resources available within DOE.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer assessed this project as highly relevant. They emphasized the critical importance of decarbonization in today’s context and highlighted SAFs as the aviation sector’s best opportunity for achieving this goal. Additionally, the reviewer noted that SAFs hold significance as a strategy for various land and marine-based systems. The presentation effectively outlined a roadmap to address the most pressing issues and challenges associated with SAF implementation, earning the highest possible relevance rating in the reviewer’s opinion.

Reviewer 2:

The reviewer stressed the project's vital role in accelerating and advancing the adoption of drop-in SAFs within the aviation sector. They acknowledged the project's value in addressing field challenges and establishing a framework for potential non-drop-in fuels of the future.

Reviewer 3:

The reviewer recognized the relevance of the work being conducted in DORMA projects 03, 17, 18, 19, 20, 37, and 38, as it contributes directly to the increased understanding and utilization of sustainable aviation fuels, thereby supporting the overarching goal of decarbonizing aviation.

Reviewer 4:

The reviewer pointed out that the project aligns with objectives within the DORMA subprogram, further underscoring its relevance and alignment with broader strategic goals.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The presentation lacked clarity regarding the overall resources allocated to this roadmap. The reviewer noted an issue with the budgets presented by the principal investigators, as it was unclear whether these figures represented yearly or total budgets. Furthermore, there was a lack of transparency regarding how much of the budget was allocated to other laboratories, partners, or contractors. The reviewer expressed the view that the budgets, especially if they include portions directed to numerous collaborators and partners, seemed generally low given the extensive scope of work outlined in the presentation.

Reviewer 2:

Regarding computational resources, the reviewer found them to be adequate. However, the reviewer identified a deficiency in experimental resources, particularly for high-pressure and high-temperature gas turbine facility upgrades at Argonne and recommended addressing this issue.

Reviewer 3:

With the exception of DORMA038, the reviewer believed that the resources allocated to DORMA projects 03, 18, 19, 20, 37, and 38 appeared sufficient for both current work and work planned for FY 2024. Nevertheless, the reviewer pointed out that assessing the adequacy of resources for achieving the full set of project goals beyond FY 2024, for which limited details were provided in most cases, remained a challenge.

Reviewer 4:

The reviewer concluded that the resources devoted to the project as a whole were sufficient.

Presentation Number: DORMA018
Presentation Title: SAF Combustion & Soot Processes
Principal Investigator: Julien Manin (Sandia National Laboratories)

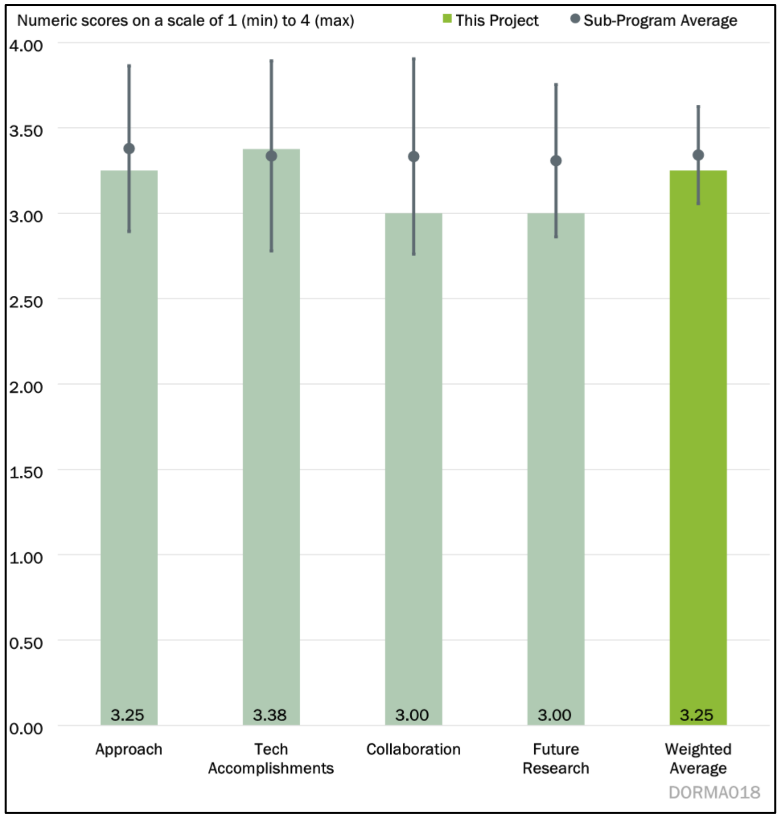

Figure 3-17 - Presentation Number: DORMA018 Presentation Title: SAF Combustion & Soot Processes Principal Investigator: Julien Manin (Sandia National Laboratories)

Presenter

Julien Manin, Sandia National Laboratories

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The approach appears to be a well-thought-out strategy, focusing on applying the established optical diagnostic laboratories and capabilities of Sandia National Laboratories to study SAF combustion in gas turbines. However, the reviewer raised concerns about the relevance of non-turbine test chambers and facilities, suggesting that a more specific alignment with gas turbine combustor designs would be valuable. While there is likely immediate progress to be made, the reviewer expressed the limitation of relying on a single-hole spray originating from reciprocating engines and highlighted the importance of considering gas turbine applications. The combination of spray experiments, soot experiments, and kinetics and CFD was commended as a comprehensive approach to leverage all available capabilities for achieving the project’s goals.

Reviewer 2:

The reviewer found the technical approach sound and consistent with other spray research in the literature, although not necessarily focused on SAFs. The reviewer emphasized the appropriateness of the combined study of non-reacting and reacting sprays. However, they sought clarification on how the team targeted droplet sizes and whether these sizes align with specific nozzle types or manufacturers. The reviewer cautioned about potential variability in droplet sizes across the industry and emphasized the importance of diligence in selecting an appropriate range of droplet sizes. Additionally, they expressed curiosity about the altitude condition, particularly regarding the feasibility of testing at a higher altitude, such as 35,000 feet, considering the significance of auxiliary power unit (APU) start at altitude conditions.

Reviewer 3:

The reviewer recognized the team's excellent progress and found the timeline reasonable. They acknowledged that while the choice of a SHA may not be directly relevant to real engine interpretation, the team is addressing a critical gap in fundamental fuel chemistry, soot study, and model development for SAF implementation.

Reviewer 4:

The approach was considered interesting and likely to yield new insights into sprays and soot formation for SAFs. However, the reviewer pointed out that the experimental systems for spray measurements appeared more suitable for internal combustion engines, such as diesel engines, rather than aviation gas turbine engines. The team itself acknowledged this challenge and barrier, specifically highlighting the need to enhance mixing to better match conditions found in modern aero-engines, as indicated on Slide 18.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer commended the completion of databases for SAF mixing, ignition delay, and lift-off length, considering it an excellent contribution to advancing SAF knowledge rapidly. Similarly, the successful completion of a reduced kinetic mechanism for C4 fuel was acknowledged as excellent progress. The reviewer noted that many facets of the project appeared to be making excellent progress, especially considering that the project is in its second year of a 5-year timeline. They anticipated more robust accomplishments as the groundwork laid in the early stages of the project matured. The reviewer also found the altitude chamber for contrail research to be an intriguing and valuable addition, as it has the potential to build new fundamental datasets related to soot and SAF. They requested that the researchers continue to demonstrate how all project tasks could be more fully integrated toward the distinct goals of SAF combustion, soot processes, and contrails.

Reviewer 2:

The reviewer found the technical accomplishments to be strong, particularly in demonstrating the capability to acquire non-reacting and reacting spray data, which they considered a challenging aspect of this work.

Reviewer 3:

The reviewer noted the team's good initial progress in acquiring and interpreting data related to fuel evaporation regimes and analysis at trans-critical conditions, an area less investigated in the aero-engine community. They also recognized the team's efforts in characterizing flame liftoff and ignition delay times, encouraging further investigation into lean-and-rich blowoff and flashback characteristics. The reviewer suggested conducting a parametric study over a broader range of conditions, beyond just take-off and cruise conditions, to benefit the community.

Reviewer 4:

The reviewer stated that the technical accomplishments achieved thus far were impressive and were expected to provide valuable insights into spray dynamics and ignition, despite differences with aviation gas turbine conditions. The development of a new altitude chamber for contrail formation study was highlighted as a significant achievement.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer commended the excellent collaboration observed within the project, emphasizing the engagement across government laboratories, universities, and relevant industrial partners. They encouraged continued engagement and integration of the perspectives and input of industrial OEMs, recognizing the importance of their involvement.

Reviewer 2:

The reviewer noted the identification of a strong team and mentioned that a few bullet points were dedicated to the partners. However, they expressed that it was not entirely clear what the partnerships were contributing to the work. They urged the team to provide clearer insight into the specific contributions and roles of their partners.

Reviewer 3:

The reviewer further encouraged the team to collaborate with relevant engine OEMs for combustion research and develop a plan for model and technology transfer to facilitate industry validations.

Reviewer 4:

The researchers were acknowledged for their excellent work in identifying issues of interest to the aerospace community, particularly through interactions with OEMs and National Aeronautics and Space Administration (NASA) Glenn Research Center.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer found the proposed research promising for advancing the three areas of spray mixing, soot, and contrails. They encouraged continued engagement with gas turbine OEMs and suggested that their insights should guide the project’s direction within reasonable bounds. While acknowledging the validity of using the SHA for fundamental physics understanding, the reviewer recommended that future efforts consider building, developing, or utilizing specific combustors and injectors for turbines. The reviewer proposed the idea of establishing a project similar to Engine Combustion Network’s “Spray-A/B/C/D” but focused on a canonical “Spray-SAF.”

Reviewer 2:

The reviewer supported the proposed future work as the right path but expressed concerns about the level of risk involved. The reviewer emphasized the need for the project to fully utilize its altitude capability and conduct diagnostic tests in the altitude chamber. Additionally, the reviewer suggested increasing the altitude, if possible, to better capture the low-pressure, low-temperature atomization characteristics of SAFs, with specific implications for APU altitude start conditions.

Reviewer 3:

The reviewer inquired about the team’s coordination with other computational aero-engine SAF research activities at Argonne and the National Renewable Energy Laboratory. The reviewer pointed out that combustion in industrially relevant configurations spans a wide spectrum of length and time scales and suggested exploring studies on the impact of turbulence, fuel temperature, and additives on SAF fuel combustion.

Reviewer 4:

In conclusion, the reviewer considered the proposed future research efforts on spray atomization and mixing to be logical. The reviewer noted that the value of the work for aero-engines might be somewhat limited by the current experimental systems' constraints. However, the reviewer found the combustion and soot formation research to be valuable for exploring SAF properties, and the contrail formation research to provide interesting fundamental data.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer acknowledged the clear alignment of the research with decarbonization objectives in the context of SAF and aerospace gas turbines. The research was considered highly relevant, particularly as alternative propulsion sources may not be feasible in the near term.

Reviewer 2:

This research addresses gaps left by the National Jet Fuel Combustion Program (NJFCP) and is highly relevant. The significance of the work on soot modeling and contrail formation modeling that can build upon this foundation was also noted. Overall, this project is seen as highly relevant and impactful.

Reviewer 3:

The reviewer pointed out that topics related to fuel mixing, fuel chemistry, soot, and contrail modeling for alternate fuels are of industrial relevance and require substantial research efforts. The critical nature of this research for the successful down selection of fuels and combustor systems for future aircraft platforms was emphasized.

The project was confirmed to be relevant to DORMA, reinforcing its alignment with broader program objectives.

Reviewer 4:

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The resources at hand were deemed sufficient for leveraging the existing laboratories and staff that traditionally focused on reciprocating internal combustion engines. However, the reviewer emphasized that if a shift is made toward gas turbine-specific laboratories, the current resources would be vastly insufficient. They expressed support for such a shift but stressed the need for commensurate increases in funding to adequately support the transition.

Reviewer 2:

The reviewer found that the project appears to be sufficiently funded, although they noted that the depth of partner involvement and the allocation of the budget to partners were not entirely clear. Nevertheless, the budget was considered sufficient for the scope of work presented, which included the development of altitude capability.

Reviewer 3:

The reviewer saw both experimental and computational resources as adequate for the project's activities.

Reviewer 4:

The resources available for the project were viewed as sufficient by the reviewer for making progress with the current experimental systems.

Presentation Number: DORMA019
Presentation Title: Multi-phase flow studies of SAFs for industry-relevant conditions and geometries
Principal Investigator: Brandon Sforzo (Argonne National Laboratory)

Presenter

Brandon Sforzo, Argonne National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 67% of reviewers felt that the resources were sufficient, 33% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

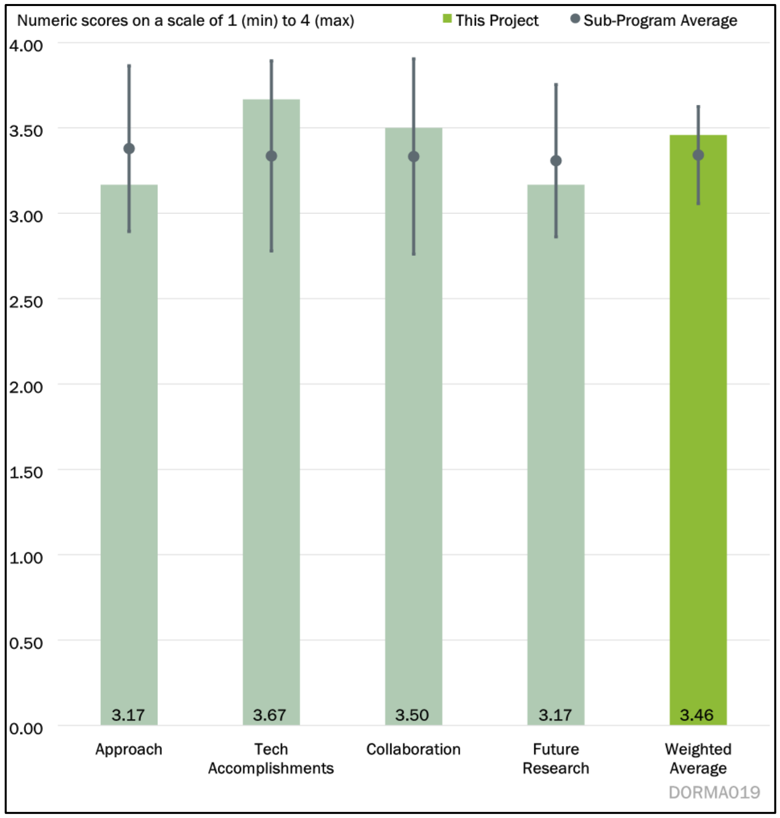

Figure 3-18 - Presentation Number: DORMA019 Presentation Title: Multi-phase flow studies of SAFs for industry-relevant conditions and geometries Principal Investigator: Brandon Sforzo (Argonne National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer found that the project presented a clear roadmap for understanding fuel spray through the use of X-ray imaging. It was noted as a novel and one-of-its-kind approach. The reviewer expressed curiosity about the omission of sub-atmospheric conditions, given that a previous presentation had identified altitude re-light as a critical aspect of SAF research, with implications for the spray.

Reviewer 2:

In the reviewer’s assessment, the absence of high-pressure continuous flow capability at Argonne raised concerns about schedule risks. It was emphasized that measurements should be conducted and analyzed under the relevant pressure and temperature conditions and, ultimately, under the relevant reacting conditions. The reviewer also recommended that Argonne explore additional diagnostic methods, including X-ray-based techniques, to acquire quantitative data for comparisons.

Reviewer 3:

From the reviewer’s perspective, future testing under higher temperature and pressure conditions holds the potential to uncover differences in fuel injection and atomization, or transcritical behavior, between conventional Jet-A and various SAFs. The detailed X-ray imaging data was seen as having strong potential to enhance fuel injection and atomization models for any hydrocarbon fuels, whether Jet-A, SAF, or blends. The reviewer noted that the real fluid modeling and CFD tasks aligned with the overall objectives of this work.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer remarked that this project ranks at the top of accomplishments. The implementation of X-ray imaging in industry-relevant fuel injectors with different fuels is considered a major achievement. The reviewer expressed a wish that this presentation had more time to delve into the takeaways from these images but acknowledges the significant value of this dataset to the SAF certification and acceptance community and its stakeholders.

Reviewer 2:

The reviewer commented that the initial spray assessment of jet fuel vs. SAF fuel results offers insights into expected performance. Trends were also demonstrated to be consistent with previous NJFCP studies and in line with industrial experience.

Reviewer 3:

The reviewer stated that experiments with X-ray imaging have been completed for an NJFCP referee injector and a Woodward non-proprietary injector, including two approaches for liquid atomization in aircraft engine combustors. Progress was also demonstrated in the real fluid modeling and atomization CFD.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer noted that the presentation showed a strong team of collaborators and even highlighted instances where partners had contributed hardware or offered cost-sharing. For instance, the NASA funding of the Woodward injector, designed specifically for X-ray imaging, was cited as a demonstration of a strong team. The reviewer mentioned that it would have been desirable to see the contributions of the many other team members mentioned at the beginning but recognized that time constraints may have prevented that.

Reviewer 2:

The reviewer acknowledged that Brandon and the Argonne team have had excellent collaborations with NASA, Air Force Research Laboratory, Office of Naval Research, OEMs, and select universities. However, the reviewer also encouraged Argonne to consider opening this study and expanding collaboration with other laboratories, such as Sandia and the National Renewable Energy Laboratory.

Reviewer 3:

The reviewer pointed out that this project involves participation by multiple engine OEMs and other government agencies, which appears to be instrumental in guiding this work toward conditions and injectors of practical interest.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer affirmed that the proposed future work is appropriate. The phased approach introduced at the beginning makes sense, and transitioning from atmospheric conditions to more challenging conditions is a logical progression. However, the reviewer noted potential risks and suggested that it would be beneficial to illustrate how this transition will be achieved with the Advanced Photon Source (APS). Additionally, some justification for the focus on high-power conditions for the spray as opposed to altitude conditions would be warranted. The reviewer commented that the proposed analysis and modeling are well-suited to the project's objectives. The reviewer also pondered, albeit recognizing it might be beyond the scope of this presentation, whether it would be possible to simulate the effects of radiation heating the spray or pre-heat the fuel nozzle.

Reviewer 2:

The reviewer observed that addressing Argonne's facility needs is essential for the lasting impact of this effort.

Reviewer 3:

The reviewer mentioned that this work began in FY 2022, and the presentation outlines future work up to FY 2024, although a specific timeline is lacking. The reviewer recognized the significance of addressing high-temperature and high-pressure conditions and stated that this would likely yield valuable test data. The plans for real fluid modeling and CFD of liquid atomization were deemed reasonable.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer emphasized that this project holds high relevance to the certification and acceptance of SAFs and is of great importance to stakeholders such as OEMs. The utilization of the APS to image the fuel spray in relevant hardware under realistic conditions with actual fuels is truly pioneering and represents a unique endeavor in this field. The reviewer expressed the belief that this work will be exceptionally valuable to modeling and simulation teams and will serve to refine their understanding of the effects of fuel properties on sprays. The reviewer commended the project for producing such challenging yet rewarding data.

Reviewer 2:

The reviewer stressed the imperative nature of this project for future OEM technology development with SAF fuels, underlining the absence of such capability elsewhere.

Reviewer 3:

The reviewer noted that simulations exploring the impact of fuels on combustor operability or emissions will require spray atomization models, and the results of this work are expected to enhance these models. The reviewer anticipated that experiments conducted at higher temperatures and pressures with X-ray imaging, in close proximity to the fuel injector exit, would yield new insights into the influence of fuel variations on liquid atomization. This, in the reviewer's opinion, is a crucial element in advancing the understanding of the use of SAFs.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer acknowledged that the resources allocated appear appropriate. They appreciated how the presentation meticulously delineated the budget allocation between experiments and modeling tasks. Furthermore, the presentation effectively outlined where cost-sharing contributions from partners were being utilized. The reviewer expressed anticipation that the high-temperature, high-pressure conditions might strain the budget but remained confident in the project's achievability.

Reviewer 2:

The reviewer noted that the absence of high-pressure, high-temperature, and high-flow capabilities represents a significant challenge, both in terms of schedule and cost for this endeavor.

Reviewer 3:

The reviewer concluded that the current resources are sufficient but foresaw a likely need for an increase or the incorporation of funding from other partners to attain test conditions approaching 50 bar and 1300°F combustor inlet conditions.

Presentation Number: DORMA020
Presentation Title: SAF Contrail Modeling
Principal Investigator: Matt McNenly (Lawrence Livermore National Laboratory)

Presenter

Matt McNenly, Lawrence Livermore National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

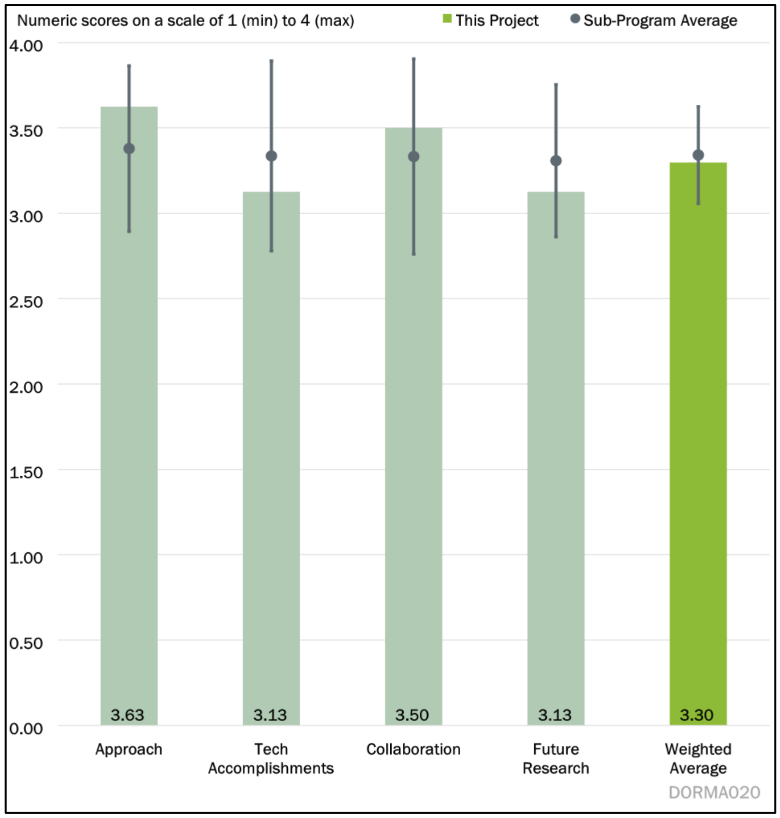

Figure 3-19 - Presentation Number: DORMA020 Presentation Title: SAF Contrail Modeling Principal Investigator: Matt McNenly (Lawrence Livermore National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer pointed out that this is a new project and commended the explanation of its motivation. The significant impact of contrail formation on the radiative forcing function and potential climate change consequences was well articulated. The project's goal to simulate the potential impact of SAF on contrail formation was highlighted.

Reviewer 2:

The reviewer found that the project is well-aligned with addressing technical barriers and providing a structured approach to overcoming them. The 2-year project was deemed to be well-planned with appropriate milestones, and the timelines were considered suitable.

Reviewer 3:

The approach to extend the LLNL chemical kinetic modeling of combustion and soot processes to ice nucleation in contrails was seen as a very promising solution to a complex problem.

Reviewer 4:

The project, according to the reviewer, covers various processes involved in contrail formation, and the team effort is well-developed. However, several comments and questions were raised by the reviewer as detailed below.

The importance of the chemical kinetic mechanism in determining the formation of precursor species and solid impurities (soot) for contrail formation and its impact on global climate change were acknowledged. The reviewer noted that while there is an abundance of literature on this topic, the project focuses on developing chemical kinetic models for the formation of species and reaction routes leading to solid impurities in SAFs.

The reviewer raised concerns about the consistency of rate constants for overlapping reactions from different component kinetic mechanisms in SAF surrogates. The reviewer recommended addressing this issue or clarifying the approach taken.

Differences between soot formation from SAFs and gasoline or diesel fuels and the process for surrogate development were queried. The reviewer suggested exploring and discussing these differences.

The inclusion of characterization of particle morphology from SAF combustion and comparisons with studies on soot particles from gasoline and diesel fuel combustion was recommended.

The reviewer sought clarification on the term "ice nucleation" and suggested that the process should involve supersaturated water vapor condensing on particle surfaces, followed by ice formation as nuclei freeze.

The simulation of heterogeneous nucleation was deemed important, but the reviewer expressed concerns about the lack of detail in its description. The reviewer recommended addressing key properties related to the energetics of the nucleation process and discussing challenges related to the irregular shapes of soot aggregates serving as condensation nuclei.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer acknowledged the thorough literature review and the focus on ice formation processes for contrail simulation in the project. The use of a self-consistency approach developed by Westbrooke and Ptiz was noted. However, the reviewer raised questions regarding the potential impact of differences in temperature and pressure conditions between the ambient cruise conditions in this research and ground-based engine combustion systems, for which the self-consistency approach was initially developed. The reviewer also inquired about whether the researchers would be using kinetics for SAF, as the presentation mainly showed standard hydrocarbons. The reason for not using SAF kinetics, if applicable, was requested.

Reviewer 2:

The reviewer expressed concerns about the progress made in the project, particularly with only two tasks completed halfway through the timeline, which were verification of kinetics and literature reviews. While the remaining milestones were marked as "On track," the reviewer suggested a more thorough tracking of progress and resource allocation.

Reviewer 3:

The reviewer acknowledged that the project is still in its early stages, with the mechanism development for computing ice nucleation in progress.

Reviewer 4:

The reviewer recognized the significant work accomplished by the research team in the first year of the project. The reviewer highlighted the importance of the literature review and requested clarification on whether the analysis and experiments would be carried out under sub-atmospheric conditions. Regarding the computational aspects of the project, the reviewer suggested that future presentations should provide more details on the nature of the computations and the computational platform used. The reviewer also emphasized the need for a surrogate-based approach for modeling SAF and soot, and requested information on the specific

SAF surrogate used, its development, and validation. The reviewer noted the significant improvements in soot volume fraction estimates from the new model and recommended a clear strategy for closing the gap. Lastly, the reviewer sought clarification on the term “homogeneous” in the context of nucleation without the presence of solid particles (soot).

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer noted that the project demonstrates collaboration with relevant individuals and organizations.

Reviewer 2:

The reviewer deemed the level of collaboration and partner selection to be reasonable.

Reviewer 3:

The collaboration with different teams at LLNL was perceived as very solid. However, the reviewer inquired about the plan to collaborate with Julien Mann at Sandia, particularly regarding the development of an altitude chamber for contrail formation research (DORMA 018). The reviewer pointed out that the presentation mentions collaborations with national laboratories, including Sandia, but does not reference the LLNL contrail modeling effort in the presentation from the Mann group. The reviewer suggested exploring and potentially strengthening this collaboration.

Reviewer 4:

The reviewer found that the collaborations include competencies covering most of the major processes involved in forming contrails, with the exception of the nucleation problem. The reviewer mentioned that it was not entirely clear how the collaborations would be coordinated. The presentation briefly mentioned various aspects such as experiments, theoretical calculations, model reduction development, and surrogate fuel recommendations, but lacked specific details. The reviewer recommended that future presentations clarify how these collaborations are integrated to meet the project’s goals.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer noted that the project has laid out a logical progression of tasks to move from the current state to the completion of the project. However, the reviewer raised concerns, particularly in response to the discussions of other reviewers, that the scope of the problem might be more substantial than what is being addressed in this research. There is a suggestion that the current project might serve as a preceding step to a larger project.

Reviewer 2:

The reviewer recognized the value of further model validation and suggested that the current project may serve as a preliminary step to a more extensive initiative.

Reviewer 3:

The approach to modeling ice nucleation and contrail formation was considered highly promising, even though it was acknowledged that this is an incredibly complex problem.

Reviewer 4:

The reviewer observed that the future work was outlined but noted that it appeared somewhat non-specific. For example, the development of nucleation and cloud physics models for homogeneous and heterogeneous processes was mentioned, but it was not clear which theoretical framework would be used (e.g., classical nucleation theory, density functional theory, molecular dynamics simulations). The reviewer also expressed interest in understanding the nature of the experiments at Sandia and their expected outcomes, as well as the SAF and soot kinetic mechanism effort. The reviewer raised concerns about obtaining property data for nucleation models, especially given the potential challenges associated with classical theory and the lack of data for properties such as surface energy on non-circular solids and the rate of condensation. The reviewer pointed out that it may be difficult to obtain these properties until the team starts developing the models. The reviewer requested more details on the SAF surrogate to be used in the simulations. The reviewer suggested the potential value of testing the capabilities developed in the project in the field, such as by fueling an aircraft and monitoring performance during a flight test. Collaboration with partners from the aviation industry or government entities like commercial airlines or the Air Force was recommended to provide real-world flight tests to assess soot emissions and contrail formation and to evaluate how well the methodologies and simulation capabilities of the project perform in practice. The reviewer highlighted the challenge of understanding the energetics of condensation nuclei formed on soot aggregates and called for a clearer explanation of how ice nucleation models would be validated, as well as clarification on the experiments to be conducted at Sandia to provide validation data.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer emphasized the importance of understanding the potential impact of SAFs on contrails.

Reviewer 2:

The project was seen as supporting the project objective, which involves building a better foundation to accurately capture the effect of SAF composition.

Reviewer 3:

The project’s relevance to the DORMA subprogram was acknowledged.

Reviewer 4:

From a broader perspective, the project was considered highly relevant, especially with the renewed interest in combustion technologies using SAFs. The reviewer underscored the critical concern of contrail formation in the context of global climate change, and how this project addresses the processes involved in their formation.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer noted that it seems that they have sufficient funds to complete the tasks associated with the research. While the resources were deemed adequate, the scope of the problem was perceived as potentially larger than what the current research was addressing, leading to the suggestion that a more extensive project might be worth considering.

Reviewer 2:

The reviewer commented that the resources look sufficient.

Reviewer 3:

The reviewer stated that the resources seem to be significant.

Reviewer 4:

The reviewer commented that while the resources were deemed adequate, the scope of the problem is potentially larger than what the current research was addressing, suggesting that a more extensive project might be worth considering. In terms of resource sufficiency, the reviewer agreed that the project had the necessary resources, but more detailed information is needed, such as overhead rates, salaries for scientists and technicians, equipment costs, etc., to provide a more comprehensive assessment. The reviewer suggested that an ultimate judgment of cost-effectiveness would require a cost/benefit analysis based on DOE investment relative to the commercialization potential and the distribution of costs among the collaborators.

Presentation Number: DORMA021
Presentation Title: Simultaneous Greenhouse Gas and Criteria Pollutants Emissions Reduction for Off-Road Powertrains
Principal Investigator: James McCarthy (Eaton)

Presenter

James McCarthy, Eaton

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

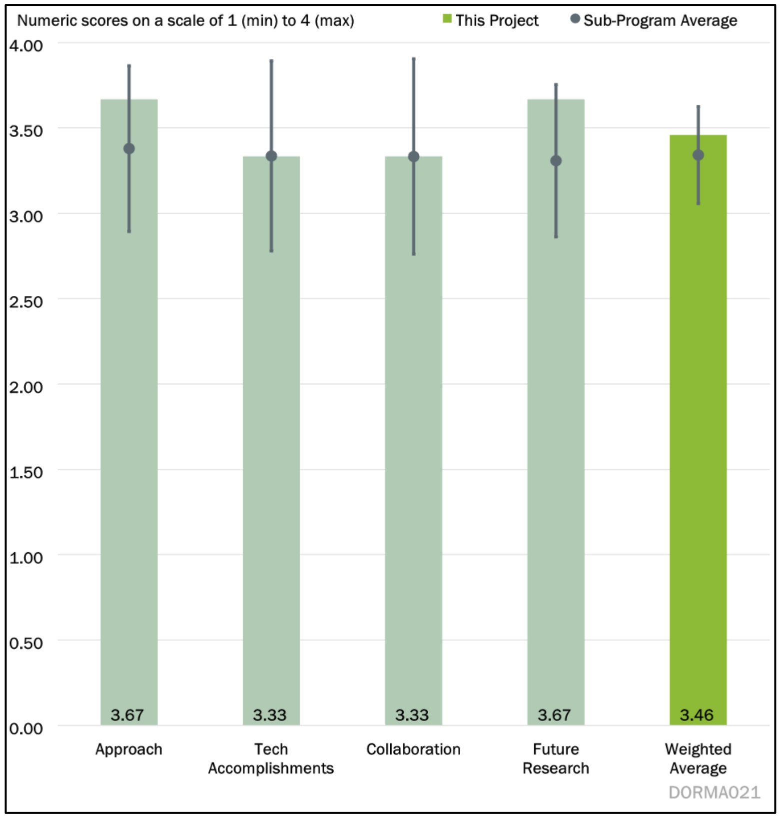

Figure 3-20 - Presentation Number: DORMA021 Presentation Title: Simultaneous Greenhouse Gas and Criteria Pollutants Emissions Reduction for Off-Road Powertrains Principal Investigator: James McCarthy (Eaton)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer stated that the project is well designed to address the technical barrier at hand. They found the timeline to be well planned yet advised the team to remain vigilant about the work at ORNL, acknowledging that work in DOE laboratories may sometimes proceed more slowly due to government structural factors.

Reviewer 2:

Another reviewer expressed admiration for the project’s outstanding approach, which goes beyond the original scope by including additional tasks to deepen the understanding of the underlying science. They particularly praised the modular, single-pass aftertreatment system concept, which allows for comprehensive analysis at each stage of the system. The plan to compare the modular system with a commercial aftertreatment system was seen as a clever move and evidence of effective collaboration within the team. The utilization of external and international collaborations was also seen as a positive aspect.

Reviewer 3:

The reviewer commented that the key barriers were adequately addressed and appreciated the project’s modular approach and transient testing across multiple cycles, enabling the assessment of a wide range of system configurations. The project’s timeline was viewed as reasonably planned. The reviewer suggested considering additional barriers not currently addressed, specifically cost and space constraints.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer expressed concern about the project's progress, noting that it has experienced delays. However, with the granted six-month no-cost extension, the reviewer expressed trust that the team will be able to complete BP 1 by November.

Reviewer 2:

In terms of technical progress, the reviewer commended the project, describing the progress made to date as excellent.

Reviewer 3:

The reviewer found the technical progress to be good and on track. They highlighted the positive development of advanced engine components such as the EGR pump, cylinder deactivation (CDA), and others, along with the aging of aftertreatment parts.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer said that the team has active collaboration among team partners. The role of Southwest Research Institute (SwRI) in this project seems not clear, and there is no report about data from SwRI in period 1.

Reviewer 2:

The reviewer mentioned that the project has clear team member roles, with good coordination between organizations.

Reviewer 3:

The reviewer understood that the progress made so far required collaboration across teams and is therefore satisfactory.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer expressed confidence in the clearly defined future work for the project, anticipating that it will likely achieve its target. They acknowledged that the testing work proposed for ORNL might take longer than planned but had trust in ORNL's ability to accomplish it with strong support from other team members.

Reviewer 2:

Another reviewer found the future work plan for BP 2 and BP 3 to be clearly defined and purposeful, and they were impressed with the project.

Reviewer 3:

The reviewer appreciated the inclusion of testing five different aftertreatment configurations over multiple transient test cycles and under aged conditions, describing it as excellent. They suggested adding chemical aging for at least one system, as it could reveal differences in performance loss and desulfation needs among the systems. Furthermore, the reviewer recommended considering modeling or sensitivity studies to show the impact of changing component designs once the results for the five systems are available. Space constraints and cost considerations were also suggested as topics to be addressed.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer emphasized that the project is closely relevant to DORMA.

Reviewer 2:

The reviewer noted that building clean, high-efficiency off-road engines is directly in line with the VTO objectives.

Reviewer 3:

The reviewer commended the project for addressing the critical need to reduce NO_x and CO_2 from non-road engines.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that the team has sufficient resources to complete this project. They suggested that ORNL might need to make more effort and provide additional resources to retain its engine research team. Overall, the team was considered to have sufficient resources.

Reviewer 2:

The reviewer remarked that the resources appeared sufficient, especially since industrial partners were willing to provide more cost share.

Reviewer 3:

The reviewer stated that the resources appeared sufficient but recommended revising them in light of the earlier recommendations to add modeling, cost considerations, space constraints, and additional tests to assess the sensitivity of results to changed component designs. The reviewer also suggested allocating resources for chemical aging, as previously mentioned.

Presentation Number: DORMA022
Presentation Title: Development of a Flex-Fuel Mixing Controlled Combustion System for Gasoline/Ethanol Blends Enabled by Prechamber Ignition
Principal Investigator: Adam Dempsey (Marquette University)

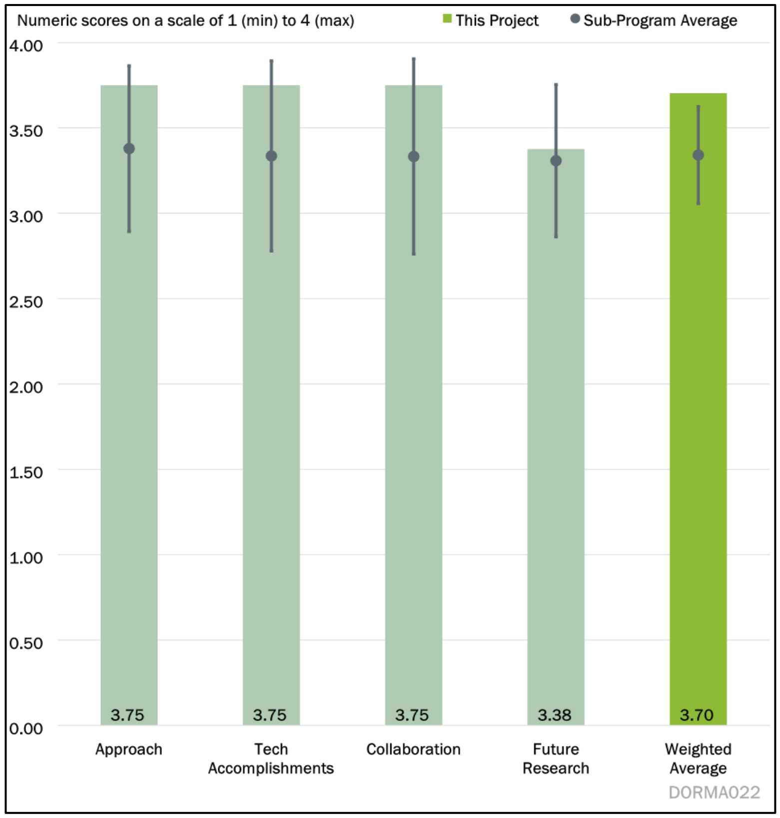

Figure 3-21 - Presentation Number: DORMA022 Presentation Title: Development of a Flex-Fuel Mixing Controlled Combustion System for Gasoline/Ethanol Blends Enabled by Prechamber Ignition Principal Investigator: Adam Dempsey (Marquette University)

Presenter

Adam Dempsey, Marquette University

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer commented that the project is well-planned and thorough, incorporating a combination of simulation and experiments (SCE). They noted that the first demonstration on SCE is sensible. The reviewer affirmed that the questions posed by previous reviewers from the prior year remain relevant, and it appeared that the project would respond to them, including a comparison to more conventional spark ignition engines. They requested that the project should follow through with a reaction to reviewer comments. Additionally, they suggested including consideration/comments of renewable diesel or biodiesel for its impact on CO_2. The reviewer questioned whether the focus on ethanol is in line with regional availability and regional interests, pointing out that CO_2 reduction with renewable diesel might yield more significant results. The reviewer further requested a discussion on the need or lack thereof for NO_x aftertreatment.

Reviewer 2:

The reviewer expressed that the researchers are very good. They praised the principal investigator for assembling an excellent, highly qualified team and acknowledged that the work is appropriately focused in areas where their strengths lie.

Reviewer 3:

The reviewer observed that it is a well-designed project with a reasonably planned timeline.

Reviewer 4:

The reviewer remarked that the project is well-laid out and has leveraged previous research using the Caterpillar single-cylinder engine. They verified that the project aims to apply these learnings to the John Deere 9 L engine. The reviewer noted that the researchers have systematically tested various low carbon fuels and pre-chamber locations, leading to the identification of the best locations for the pre-chamber. The ultimate goal, the reviewer clarified, is to be able to maintain the diesel torque curve while achieving up to a 50% reduction in life-cycle carbon emissions.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer affirmed that the overall team is strong and has made excellent progress in the design of the pre-chamber, as well as in conducting simulations and experiments pertaining to operating strategy, soot formation, and blend effects.

Reviewer 2:

The reviewer observed that very good progress has been made, and the team's future plans have been well laid out.

Reviewer 3:

The reviewer praised the principal investigator and the team for their exceptional efforts in keeping the project on track, even in the face of challenging questions that arose during the design phase.

Reviewer 4:

The reviewer noted that the project has successfully completed its first year, with estimates indicating that it is over 38% complete. The reviewer highlighted that a substantial amount of data was collected and meticulously analyzed, revealing favorable results. This, in turn, instilled confidence that the technology transfer to the multi-cylinder engine should be a successful endeavor.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer stated that the contributions of the team members are clearly explained and highly collaborative.

Reviewer 2:

The reviewer remarked that the presenter clearly articulated the work and progress of the collaborators.

Reviewer 3:

The reviewer affirmed that the presented results would not have been possible without very good collaboration among all team members.

Reviewer 4:

The reviewer observed that the project lists a total of seven collaborators, with each providing significant contributions. They clarified that these collaborators are all essential for the success of the project, encompassing an engine manufacturer, two universities, a power cylinder supplier, a fuel system supplier, an ethanol supplier, and Clear Flame. The reviewer emphasized that each collaborator will be able to provide valuable input on what needs to be addressed to bring the technology to production.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer expressed surprise at finding no summary slide for future research, except where it is included in the project timeline chart on Slide 5. They suggested considering the addition of a specific "future work" slide near the end of the slide deck, noting that it might have been overlooked by the reviewer. Additionally, the reviewer brought up the question about the need for NO_x aftertreatment, pointing out that while it might not be required by current regulations, there is a societal push for achieving emissions levels as close to zero as possible, or at least as low as the electric grid NO_x per kilowatt-hour.

Reviewer 2:

The reviewer commended the researchers for making intelligent adjustments to their planned research based on the results obtained thus far. An example provided was the adjustments made in response to results demonstrating the potential benefits of the side-mounted ignition prechamber.

Reviewer 3:

The reviewer praised the team for doing a very good job in ensuring that the next milestones are set to be successfully achieved.

Reviewer 4:

The reviewer noted that the project is well laid out, with well-thought-out project milestones for BP 2 and BP 3. They expressed confidence that as long as the project stays on schedule, it should be a success.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer stated that the project has the potential to result in an effective approach to CO_2 reduction in off-road applications, potentially with a retrofit option. The reviewer emphasized that the technology utilizes readily available fuels and fuel distribution, making it impactful in the near and mid-term.

Reviewer 2:

Reducing engine CO_2 emissions through lower carbon fuels was noted by the reviewer as a critical aspect of meeting CO_2 reduction goals in the transportation sector, especially in scenarios not conducive to electrification.

Reviewer 3:

The reviewer pointed out that the project effectively addresses the VTO goal of reducing GHG emissions from off-road HD vehicles while also supporting the production of sustainable fuels.

Reviewer 4:

The reviewer highlighted that one method to reduce the lifecycle CO_2 emissions from hard-to-electrify off-road vehicles is to convert them to a low life-cycle carbon fuel, such as green ethanol. The project enables the conversion of diesel engines to run on ethanol with similar efficiency to diesel engines. The reviewer posed the eventual question of how the demand for low carbon fuels will be met as many engines switch to these fuels.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer remarked that the resources for the project appear satisfactory. The reviewer suggested that a larger award might be needed for deployment activities.

Reviewer 2:

The reviewer noted that there was no indication that resources are limiting the proposed work, and the researchers seem to be accomplishing their goals within their budget.

Reviewer 3:

The reviewer commented that it is challenging to provide extensive commentary on project resources when DOE funding for such projects is significantly limited.

Reviewer 4:

The reviewer affirmed that the resources allocated are appropriate for the stated work.

Presentation Number: DORMA023
Presentation Title: Improved Efficiency of Off-Road Material Handling Equipment through Electrification
Principal Investigator: Jeremy Worm (Michigan Technological University)

Presenter

Jeremy Worm, Michigan Technological University

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

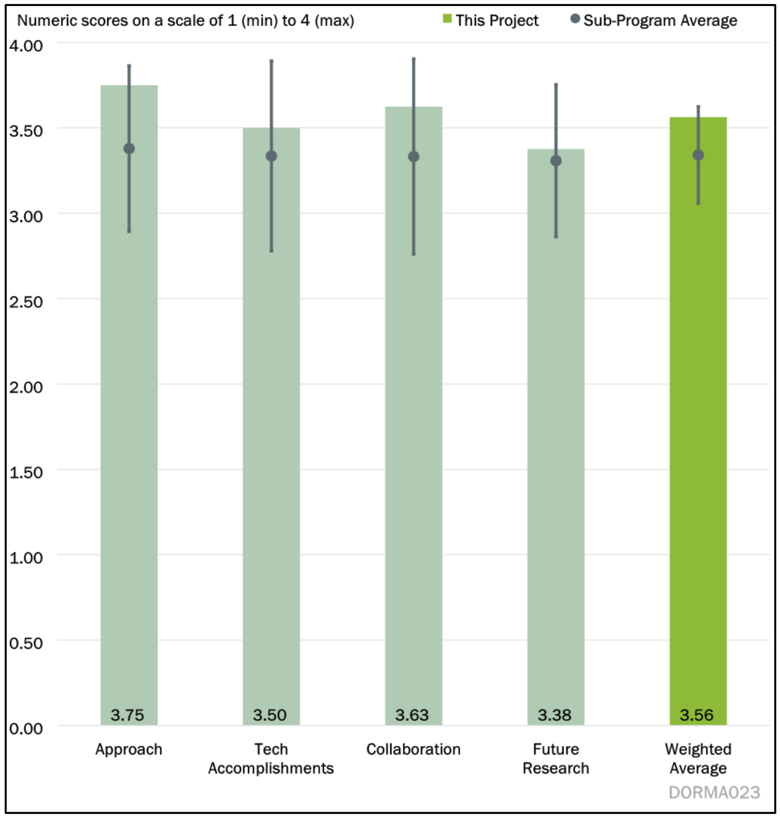

Figure 3-22 - Presentation Number: DORMA023 Presentation Title: Improved Efficiency of Off-Road Material Handling Equipment through Electrification Principal Investigator: Jeremy Worm (Michigan Technological University)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer acknowledged that the project is employing a robust analysis foundation to define the architecture of the material-moving device, aiming for maximum reduction in fuel usage while still meeting full functional mission requirements. They found the analysis of life cycle CO_2 to be very interesting and recommended the publication of that effort. The reviewer pointed out that it is not clear whether renewable, low-carbon fuels were part of the analysis and recommended their inclusion. They considered this project to be an intriguing example of achieving substantial CO_2 reduction without the precondition of decarbonizing the grid.

Reviewer 2:

The reviewer expressed that the work is highly interesting and has the potential to significantly reduce the CO_2 footprint for off-road vehicles not suitable for purely electric vehicle operation. They commended the approach through optimized control of a versatile multi-component powertrain, noting that it appears to have been executed very effectively.

Reviewer 3:

The reviewer stated that the project is well designed, and the timeline is reasonably planned. They expected significantly more progress during the second BP. The balanced approach of identifying the electrified propulsion and electrified hydraulic architecture that minimizes carbon intensity without sacrificing performance and end-user acceptance was praised. This approach was seen as adaptable to a diverse range of architectures commonly found in the off-road equipment industry. The reviewer believed that even greater CO_2 reduction could be achieved through the electrification of additional components for customers willing to pay the increased cost.

Reviewer 4:

Having selected the vehicle architecture, the reviewer noted that good progress has been demonstrated. Modeling has indicated that the CO_2 reductions should be readily achievable. They mentioned that most supply chain delays have been resolved, though some concerns still linger regarding specific sub-system parts.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer praised the excellent progress in modeling and design, noting a strong focus on the desired outcomes. As noted by the reviewer from the previous year, there remains a lack of specific information regarding the management of the machine’s cost, even though cost is identified as a potential barrier.

Reviewer 2:

The reviewer stated that the work is proceeding according to the schedule. They highlighted that the current phase, which they are entering into, is expected to be one of the most challenging. The potential for delays in component delivery, unexpected outcomes during the building and initial testing of the prototype vehicle, and other unforeseen challenges are all possible, although the researchers are mindful of these possibilities.

Reviewer 3:

The reviewer said fantastic progress had been achieved during the second BP of this project, aligning with the overall project plan. The simulation results demonstrating a 46% CO_2 reduction in a commercially viable off-road material handler using the methods identified in this project were described as very encouraging. However, the reviewer suggested that these results should be demonstrated over a broader range of real-world standard operating application duty cycles.

Reviewer 4:

The project has advanced to being over 70% complete and is on track to be finished by Mar. 2024, which the reviewer considered achievable. The reviewer noted that all the expected tasks have been completed, including the major decisions made, such as selecting the vehicle architecture and transitioning to a load-following electrified hydraulic system to enhance hydraulic efficiency. Models have indicated potential fuel consumption reductions of up to 46% compared to conventional vehicles.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer noted that the roles and contributions of the diverse team members have been clarified this year.

Reviewer 2:

The reviewer praised the excellent collaboration within the project. They stated that based on the presentation, the comments of the presenter, and the progress that has been made, it appears that all the collaborators are fully engaged.

Reviewer 3:

The reviewer emphasized that the interactions and collaborations within the project team are well-demonstrated. They highlighted that the project has well-defined roles and responsibilities for all the partners, including Michigan Tech (Aps Lab), Pettibone, Parker, EMP, Cascadia Motion, eMatrix, Torsion Control Products, Meritor, Cummins, and Pukall Lumber Company.

Reviewer 4:

The reviewer expressed appreciation for the table showing all the collaborators and how they have contributed. They concluded that with all this collaboration, the project has a good chance of success.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer stated that the team is still faced with much to accomplish in order to reach their goals and complete the project. However, they demonstrate a good understanding of the next steps.

Reviewer 2:

The reviewer observed that the future work has been clearly laid out, and the researchers appear to be aware of the challenges and potential pitfalls that lie ahead. They found the potential for this control approach to be applied to other off-road applications very exciting, enhancing the work’s potential impact in a significant sector of the mobility arena.

Reviewer 3:

The reviewer stated that the proposed work for the third year has been clearly defined. They appreciated seeing that the physical build has already commenced, and all major hardware design efforts are complete, with major components on order and the remaining design efforts focused on minor components.

Reviewer 4:

The reviewer highlighted that the last part of the project involves completing the demonstration vehicle and verifying the fuel efficiency goals. The schedule appears to be a bit tight, leaving not much time for full vehicle testing.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer observed that the project holds the potential for substantial CO_2 reduction within the off-road sector. It does not necessitate the prerequisites and delays associated with decarbonizing the grid and the challenges of recharging equipment in the field, particularly if the use of renewable liquid fuel is considered.

Reviewer 2:

The reviewer stated that the work is proceeding according to the schedule. They highlighted that the current phase, which they are entering into, is expected to be one of the most challenging. The potential for delays in component delivery, unexpected outcomes during the building and initial testing of the prototype vehicle, and other unforeseen challenges are all possible, although the researchers are mindful of these possibilities.

Reviewer 3:

The reviewer expressed that this project aligns with the broader objectives of the VTO subprogram, particularly focusing on Electrification and Energy Efficient Mobility Systems (EEMS).

Reviewer 4:

The reviewer remarked that the models used in the project have indicated that it could surpass the 20% fuel efficiency goals, potentially achieving over 40%. They noted that it will be intriguing to observe whether the demonstration vehicle can indeed achieve these impressive fuel efficiency values.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer noted that it was not clear whether any team members besides Michigan Technological University would receive DOE funds.

Reviewer 2:

The reviewer remarked that the work is progressing as proposed, which suggests that the resources are sufficient.

Reviewer 3:

The reviewer said that based on what has been completed so far and the work left, the resources should be sufficient to achieve the stated milestones for the project in a timely manner.

Reviewer 4:

The reviewer commented that the project appears to be on budget and has sufficient funding to complete the project.

Presentation Number: DORMA024
Presentation Title: Reduced Cost and Complexity for Off-Highway Aftertreatment
Principal Investigator: Ken Rappe (Pacific Northwest National Laboratory)

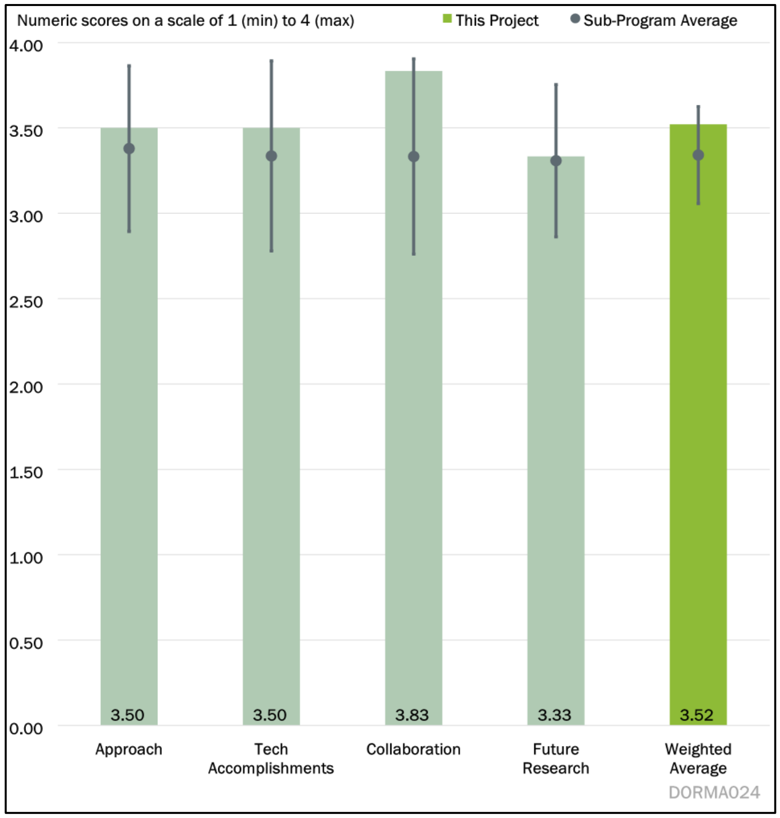

Figure 3-23 - Presentation Number: DORMA024 Presentation Title: Reduced Cost and Complexity for Off-Highway Aftertreatment Principal Investigator: Ken Rappe (Pacific Northwest National Laboratory)

Presenter

Ken Rappe, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 67% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 33% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer expressed that this project effectively addresses the high-cost barrier associated with after-treatment systems for diesel engines. They found the project to be well designed with all the necessary components in place for its success. The timeline is well-planned, a judgment substantiated by the information presented and their thirty years of experience in this area.

Reviewer 2:

The reviewer remarked that a strong project team is working on a technically feasible solution involving a diesel oxidation catalyzed filter (DOCF) for integrating aftertreatment. The Michigan Technological University (MTU)/John Deere team has established itself as a leader in this field for nearly thirty years. The project was praised for its adaptability when Carus was unable to deliver on the promised catalyst materials. The reviewer expressed that it’s expected John Deere’s supplier will offer more implementation-ready solutions. However, more engine testing would be preferable to additional bench tests. They also questioned the absence of clarity regarding transient testing in the project.

Reviewer 3:

The reviewer observed that the project’s approach encompasses the use of modeling and detailed laboratory-scale characterization to comprehend, design, and predict the performance of the new multi-functional component. The reviewer highlighted that the project also involves engine studies to explore performance under practical conditions. The initial emphasis appears to be on fundamental studies at the laboratory scale and model development. The impact of ash and soot management is taken into account. However, there is some lack of clarity regarding the range of designs to be explored, such as washcoat loads, the extent of zone coating, platinum-palladium (Pt-Pd) ratios, operating conditions, and more. Furthermore, it remains unclear how aging of the component is being studied, encompassing hydrothermal and chemical aspects.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer stated that research team has made excellent progress in this project, and this is supported by the information presented in Slides 7 to 14.

Reviewer 2:

The reviewer expressed a desire to see error analysis included on the plots. They found the ash results interesting but questioned how this information will help overcome ash-related issues. They sought clarification on how the new knowledge gained will translate into actionable plans for the device. The reviewer noted that the engine experimental work was particularly well done.

Reviewer 3:

The reviewer noted that a pathway for a 20% platinum group metals (PGMs) reduction has been identified. The DOCF model has been developed, with reaction kinetics calibrated based on available data, and the inclusion of zone coating. The reviewer mentioned that NO_x chemistry has been updated. They noted that the exploration of ash interaction with the catalyst is conducted using advanced characterization tools. The reviewer expressed a need for clear definition of the expected outcome, as similar microstructure-scale work has been done previously, including by the project participants. As it stands, this aspect appears somewhat disconnected. The laboratory reactor measurements were appreciated for providing insights into the DOCF performance at the channel scale and the impact of zone coating, washcoat loading, and other factors.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer commented that the team has clearly presented the work conducted by each partner. The reviewer suggested that this project should be rated as a project with very active collaboration among the partners in this team, as demonstrated in Slide 16.

Reviewer 2:

The reviewer noted that all participant roles are clear, and several team members, including Pacific Northwest National Laboratory, John Deere, and Michigan Technological University, have previously collaborated on projects.

Reviewer 3:

The reviewer expressed that all team members are contributing with various strengths, providing hardware, laboratory studies, modeling, and characterization.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer observed that the team had clearly defined the purpose of future work in Slide 18. The reviewer was confident that the future work had a high likelihood of achieving its target, as this was justified by the progress of this project and the reviewer's thirty years of work experience.

Reviewer 2:

The reviewer noted that transient testing was needed and found that plans for it were unclear.

Reviewer 3:

One limitation the reviewer identified in laboratory reactor studies was that the feed gas, which was an approximation of real engine exhaust, might impact the results. The reviewer suggested that the authors explore the sensitivity of any conclusions from this work to the composition of the feed gas. The inclusion of real engine experiments was commendable, as it provided the most practical learning. Given that the model had been developed, the reviewer recommended conducting additional verification with varying zone coating lengths and Pt/Pd distributions to ensure that it captured the chemistry beyond a narrow window. It was imperative for the model to be able to extrapolate to a wide range to assist in optimized catalyst design. The reviewer also emphasized the importance of presenting the results with the impact of hydrothermal and chemical (sulfur, potassium) aging. The reviewer suggested that combining the functionality of a diesel oxidation catalyst (DOC) and diesel particulate filter (DPF) into one component could potentially reduce backpressure. The team should have provided an estimate of the improvement at various soot loadings.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer stated that it was closely relevant to DORMA.

Reviewer 2:

The reviewer affirmed that this project directly supported VTO objectives and exemplified laboratory-university-industry partnering to address real barriers to lower-cost emissions control.

Reviewer 3:

The reviewer emphasized that reducing PGM usage and making components compact for use with upcoming low NO_x systems was an important aspect of emissions reduction from HD equipment.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer noted that they had more than they needed to complete this project, benefiting from the strong support of team partners and the active involvement and participation of each partner.

Reviewer 2:

The reviewer verified that the project funds appeared to be sufficient.

Reviewer 3:

The reviewer observed that the team seemed well-equipped to handle the targets on time and within budget.

Presentation Number: DORMA025
Presentation Title: Fully Electric Powered, Hydraulic Assisted, Compact Track Loader
Principal Investigator: Perry Li (University of Minnesota)

Presenter

Perry Li, University of Minnesota

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

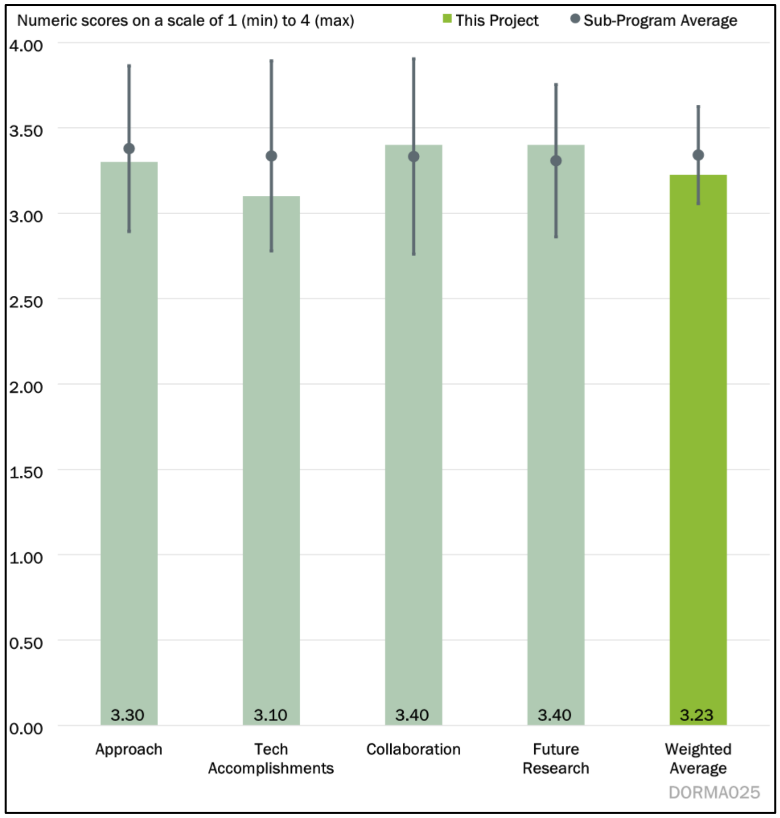

Figure 3-24 - Presentation Number: DORMA025 Presentation Title: Fully Electric Powered, Hydraulic Assisted, Compact Track Loader Principal Investigator: Perry Li (University of Minnesota)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer remarked that the goal is to use an hybrid hydraulic-electric architecture (HHEA) to maintain the high-power density of hydraulics and to improve the overall energy efficiency of the powertrain by not relying on relatively large electric machines. The team is using multiple valve options to charge the various hydraulic rails on the machine, thus the electric motors needed are small compared to what would be needed for electric propulsion or loader arm lift.

Reviewer 2:

The reviewer stated that the project is well designed, technical barriers are addressed, and the timeline is reasonably planned. However, the proposed HHEA with multiple pressure rails may be unnecessarily complex and costly for the compact construction equipment sector, which is very cost-sensitive. It is understandable to use hydraulics for high-power density work functions but not for the propel circuitry. The reviewer affirmed that a costed bill of materials comparison between the baseline and proposed architecture will be helpful.

Reviewer 3:

The reviewer expressed that the approach is very good, a combination of simulations and hardware-in-the-loop laboratory work. There are still a lot of technical barriers, but the team has good ideas on how to tackle them. The timeline seems to be reasonable. The reviewer raised a question, asking, “I believe there is a mistake on Slide 19 (BP 3 is probably July 2024 to June 2025)? My concern is related to the ability to smoothly switch without having an impact on machine controllability and finding components that will be suitable for that.”

Reviewer 4:

The reviewer exulted that an interesting concept is developing a fully electric hydraulic-assisted vehicle. The main barrier is overcoming the low efficiency of the existing throttled control hydraulic pump for transferring the engine's energy to the hydraulic system. This is overcome by using a high-efficiency Danfoss digital displacement pump and using three to four different pressure rails and fast switching valves to control the necessary flow rates. The reviewer praised this approach, stating that the system is more cost-effective than a fully electric version and should be able to use mostly off-the-shelf parts. The reviewer verified that the project should have a high probability of success.

Reviewer 5:

The reviewer commented that the approach section and overall work could be enhanced with a more descriptive overview of the HHEA. On Slide 4, the HHEA schematic shows two pressure sources plus a tank as modulating hydraulic forces to control the actuator piston. The electrical side is represented as a pump drive, with no distinguishing sequence for how pressure regulation is done on the mid and high-pressure lines. The reviewer questioned the reason for the "optional" pressure augmentation on one side of the piston arrangement and noted that the reference to a previous study is accompanied by a picture that gives no information to substantiate the savings or downsizing claims reported. On the proposed electric powered compact track loader (CTL) with HHEA (Slide 5), the reviewer asked what the authors are trying to convey here and whether there are any unique features on the Danfoss E96 pump worthy of note. The reviewer clarified that the approach could be strengthened with a clear energy audit of the baseline product, the hydraulic-electric, and electric variants. Additionally, the reviewer observed that the project appears vague, as noted by the need to differentiate HHEA from "alternative" schemes, providing measurable targets for "fast" pressure switching. The reviewer sought to verify if it is possible to provide more details on the baseline - current product. The reviewer concluded by observing that the six-tier approach is clear, with Step 1 providing a baseline of the technology readiness level and suggested that it may be helpful to understand to what next level the work aims.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer acknowledged that the team was somewhat fortunate that the propel circuit efficiency is estimated to be as good as it is. The reviewer noted that it's positive that the work circuit is very efficient, and thus the overall improvement aligns with the project target. The reviewer commented that the combined donut-pie chart on Slide 18 is quite confusing and does not effectively communicate the results. The reviewer suggested that a Sankey diagram or a similar visualization would be more useful for illustrating the smaller input power and smaller losses of the electric HHEA powertrain.

Reviewer 2:

The reviewer praised the proposed concept as innovative and acknowledged the very good technical progress made compared to the project plan. However, the reviewer pointed out that there are some technical challenges that need to be addressed, specifically concerning the controllability of the pressure rail switching valve system. The reviewer noted that the valves will need to be operated at very high speeds to minimize throttling losses.

Reviewer 3:

The reviewer expressed satisfaction with the fact that the principal investigator acted on their suggestion from last year related to the assumptions about the energy used by the propel circuit vs. implement circuit. The reviewer also commended the progress in defining a solution for feeding multi-pressure rails with one pump, particularly the use of a digital pump. The reviewer indicated curiosity about the pump size needed to provide flow to different pressure rails. The reviewer also expressed contentment with the principal investigator's examination of different operating cycles to understand the potential for energy savings. The reviewer did, however, point out that packaging and integration of all components may become a challenge, and that cost and controllability still need to be demonstrated.

Reviewer 4:

The reviewer stated that the project appears to be on schedule and meeting the various milestones. For BP 1, the reviewer noted that the five milestones were met, with the most important one showing over 40% electricity savings (approximately around 43%).

Reviewer 5:

On Slide 8, the reviewer suggested that the author could elaborate on the relationship between the five representative cycles and the energy distribution regarding whether the ranges reflect the cycles and how the efficiencies are measured. On Slide 9, concerning the models of HHEA, the reviewer commented that it is not clear whether the work was able to firm up and provide, “optimum” configurations for the parameters studied. The reviewer found the report to be overly generic and suggested providing a representation of the number of pressure rails, hydraulic motor size (i.e., variable displacement?), gear ratios for electrical assist, and so on. On Slide 10, the reviewer noted that the presentation is a bit unclear when tables are given in HHEA percent efficiency and percent savings vs. electrical. The reviewer suggested that it might be best to provide a table of efficiencies for stock, HHEA, and electrical across all five duty cycles. On Slide 11, regarding the losses pi-charts, the reviewer found them hard to follow. The reviewer also questioned the statement “If diesel-downsized engine is retained” and asked whether the savings are further vs. the baseline and if there would be any compromises. On Slide 13, the reviewer found the schematic rather poor in quality and saw an opportunity to show the system layout and overlay or compare it with the actual hardware shown on the same slide, such as indicating the four drive motors, arm motors, control valves, etc. On Slide 15, the reviewer expressed difficulty in understanding the “soft-switch” concept and its loss reduction and suggested it would be easy to describe this technically with time traces of the pressure and motion control.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer affirmed that it appears the project team members are appropriately contributing to the overall effort and results on the project.

Reviewer 2:

The reviewer commended that the responsibilities as well as contributions from collaboration partners in academia (University of Minnesota and The University of Wisconsin-Madison) and industry (CNH Industrial, Danfoss, and Parker) are clearly defined, stating, “Well done!”

Reviewer 3:

The reviewer noted that there is no real insight provided on collaboration, but the reviewer found it reassuring to see that the analysis of the base machine cycles was completed, indicating that the OEM provided the necessary data to conduct the analysis. The reviewer expressed confidence in the project’s partners’ capabilities and stated that the confidence to deliver on the project objective is satisfactory.

Reviewer 4:

The reviewer recognized that the project has the appropriate partnerships with two universities (University of Minnesota, University of Wisconsin), Danfoss, Parker, and the most important one, New Holland. The reviewer noted that the project is making good progress on the modeling (from the universities) and also on the hardware (loader frame, pumps, rails, and inverters). The reviewer observed that all team members appear to be contributing and making good progress.

Reviewer 5:

The reviewer commented that the project assembles a strong team and encouraged the team to provide more information to see or understand their specific contributions to the project, particularly on the technical side.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer noted that the team is revising their plan for the propel circuit dynamometer to accommodate long lead times. The original dynamometer was a regenerating electric dynamometer, but the team will now use an electro-hydraulic dynamometer to absorb the propel circuit power. The reviewer suggested that given the questions that have come up on this project, a techno-economic analysis would be useful to help evaluate the HHEA system versus other options.

Reviewer 2:

The reviewer affirmed that the proposed future research scope and purpose are clearly defined. Based on the progress and simulation results from the work completed to date, the reviewer expressed confidence that the future work will likely achieve its targets.

Reviewer 3:

The reviewer commented that the proposed future research is focused on a combination of controls development and simulation while starting to utilize the laboratory and parts of the machine for validation of their approach. The reviewer noted that this second phase will determine if real challenges related to the soft pressure switching and the valve concept will be overcome. The reviewer raised a concern about the statement that a 10–20 ms valve response time is pretty demanding for typical off-highway equipment valves. The reviewer recommended studying component packaging and conducting a rough machine cost calculation to compare with the baseline. The reviewer also mentioned that another challenge will be the integration of electro-hydrostatic actuation or e-motor driven pump in line with the switching valve.

Reviewer 4:

The reviewer stated that the tasks for BP 2 and 3 are right on target and that the team should be able to demonstrate the vehicle near the end of the project.

Reviewer 5:

The reviewer appreciated that the steps for upcoming BPs are well described, providing a clear path to the final testing and evaluation.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer stated that the team is actively seeking to reduce energy use, thereby minimizing GHG emissions from a compact track loader and similar small non-road machines.

Reviewer 2:

According to the reviewer, the project aligns with and supports the overarching objectives of the VTO subprogram in Analysis, Electrification, and EEMS.

Reviewer 3:

The reviewer found the approach to be highly relevant. The project's objectives strongly bolster efficiency improvements in off-highway machines, consequently contributing to decarbonization goals by leveraging the strengths of both hydraulic and electrical systems.

Reviewer 4:

The reviewer stated that the off-road sector poses unique challenges in terms of electrification, and the HHEA concept significantly enhances overall vehicle efficiency when compared to traditional engine-powered vehicles. The incorporation of pressure rails should reduce the need for larger electric motors, thereby reducing overall costs. The reviewer expressed confidence that this architecture holds real promise for success.

Reviewer 5:

Off-road vehicles heavily rely on electro-hydraulics to deliver high power. Electrification is recognized as a pathway to enhance efficiency. Nevertheless, the reviewer acknowledged that the cost of high-power/torque electric machines remains a challenge. The proposed architecture integrates hydraulic and electric actuations, aiming to achieve improved efficiency, enhanced control performance, and a cost-competitive approach to high-power electric machines.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer confirmed that the resources appear sufficient to complete the project as planned.

Reviewer 2:

The reviewer, based on the spending rate to date and the proposed future research work, expressed confidence that the resources of the project should be sufficient.

Reviewer 3:

The reviewer noted that it appears the project has committed resources and strong contributors to ensure timely progress.

Reviewer 4:

The reviewer found that the resources seem appropriate, and the project team is making satisfactory progress.

Reviewer 5:

The reviewer affirmed that the resources appear sufficient for the scope of work.

Presentation Number: DORMA026
Presentation Title: Articulated Dump Truck (ADT) Electrification - Greenhouse Gas Reductions and Commercialization of New Technology
Principal Investigator: Brij Singh (John Deere)

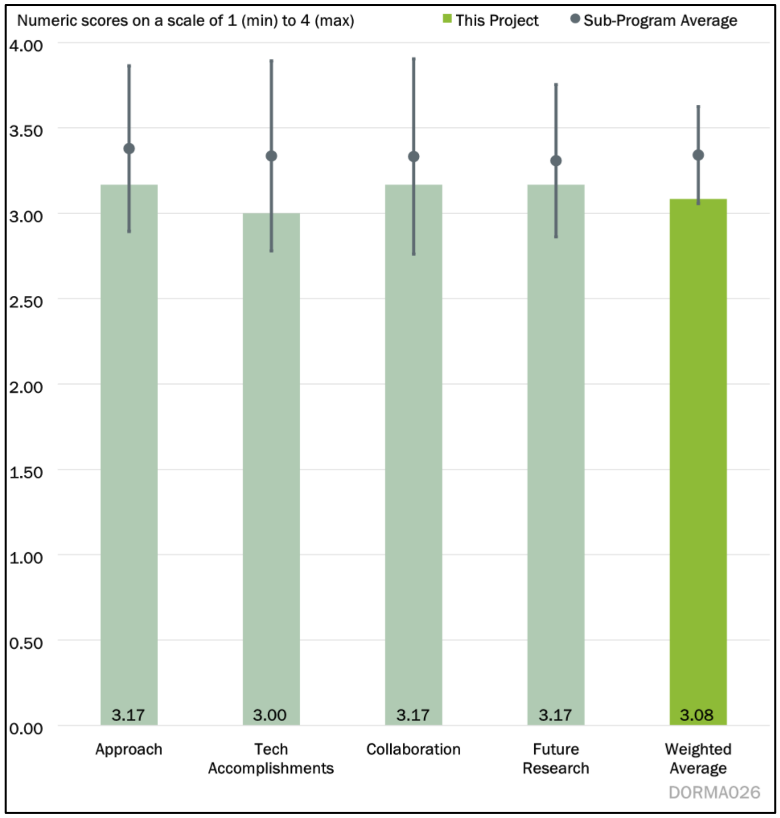

Figure 3-25 - Presentation Number: DORMA026 Presentation Title: Articulated Dump Truck (ADT) Electrification - Greenhouse Gas Reductions and Commercialization of New Technology Principal Investigator: Brij Singh (John Deere)

Presenter

Brij Singh, John Deere

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer pointed out that there is a significant amount of technical risk associated with the new technology being explored for the high-power DC/DC converters. However, the reviewer noted that the rest of the hybrid electric vehicle (HEV) powertrain work appears to build on existing components or systems for integration into a new application, the ADT. The reviewer recommended that the team also evaluate the thermal management system for the HEV architecture since there will be at least two coolant loops (high temperature for the internal combustion engine and low temperature for the battery pack and power electronics) on the ADT.

Reviewer 2:

The reviewer stated that during BP 1, the project approach was to design the components of the diesel-electric-hybrid powertrain. This was achieved through simulations to determine the sizing.

Reviewer 3:

The reviewer identified two main technical barriers. The first is the need to develop a reliable diesel-electric hybrid powertrain for the off-road market, and the second barrier is the SiC DC/DC converters needed. The project plan addresses the hybrid powertrain, and the reviewer expressed confidence that a reliable system should be able to be developed. The reviewer further noted that the auxiliary resonant commutated pole SiC inverter has the potential for significant energy savings, which will need to be verified. The overall project aims to develop an articulated dump truck that achieves over 20% fuel savings. The reviewer observed that since John Deere is leading the project, many of the technical barriers required to put a vehicle into production are being addressed, including the need for a 15,000-hour vehicle.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer raised a concern that at 15%, the progress seems relatively low, especially considering it is most of the way through BP 1. The reviewer questioned whether BP 1 was extended due to contracting-related delays. The goal for BP 1 is sizing components for the diesel-electric HEV powertrain, and the reviewer acknowledged that the team appears to be well on their way to achieving that goal. However, the reviewer recommended revisiting the battery pack sizing work to ensure that an appropriate pack is used in this application. While 35 kWh is deemed acceptable, the reviewer suggested that a more rigorous decision-making process would be beneficial.

Reviewer 2:

The reviewer commended the first-year accomplishments, which include system modeling, optimization, and prototype data collection, stating that they have made significant progress in getting the project off the ground.

Reviewer 3:

The reviewer noted that a table of milestones was provided, and while the milestones are considered pertinent, there is uncertainty regarding how many of them have been accomplished. The reviewer expressed concern that the project is reported as being 15% complete, which seems low for this stage, as it should ideally be around 30% complete. The reviewer emphasized that, based on the presentation, there appears to be progress on all the accomplishments, but many of them are not yet complete.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer acknowledged that the project team includes John Deere and two universities. The reviewer observed that it seems several divisions within John Deere are involved, and the reviewer appreciated that this could create a feeling of having multiple industrial partners on the project.

Reviewer 2:

The reviewer found that coordination between team members was difficult to assess, particularly between the various branches within John Deere. The reviewer recommended that for future presentations, it would be beneficial to identify which collaborators contributed to each of the technical accomplishments to make this assessment more straightforward. The reviewer noted that for the current presentation, the assumption was that this information is shown in the boxes on Slide 19.

Reviewer 3:

The reviewer pointed out that the project is being led by John Deere, and there are five different groups within John Deere that are assisting with the project, which is required because different groups are needed for different system components. The two universities are providing assistance with power converters and prototyping and testing. The reviewer concluded that overall, it appears to be a good collaboration.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer understood that continuing supply chain issues have significantly increased lead times for components, particularly for HEV powertrains. The reviewer also acknowledged that there is a significant risk associated with inventing the soft-switched silicon carbide (SiC) inverter, especially for the 250 kW power levels required for the electrified ADT.

Reviewer 2:

The reviewer recommended providing more detailed context for the future work next year. For instance, the reviewer pointed out that a statement like “Additional testing of early prototype of 310E electrified ADT” does not clearly convey the specific goals of the testing.

Reviewer 3:

The reviewer commented that the proposed future research tasks are presented in a relatively high-level format. The reviewer expressed a desire to see more details on how these tasks will be met in the future.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer noted that this project supports vehicle electrification and DORMA goals to reduce energy use and GHG emissions.

Reviewer 2:

The reviewer affirmed that the electrification of a diesel-electric-hybrid powertrain of this scale in an off-road vehicle demonstrates a reduction in GHG emissions and effectively meets the objectives.

Reviewer 3:

The reviewer highlighted the project’s goal, which is to provide fuel savings for hard-to-electrify off-road vehicles, and expressed confidence that this project is on track to meet the goal of providing over a 20% reduction in fuel consumption.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer assessed that it looks like the John Deere-led team should have sufficient resources to complete the work on time.

Reviewer 2:

The reviewer considered it early in the project to make a final judgment but found the resources allocated to be appropriate at this stage.

Reviewer 3:

The reviewer stated that the overall budget appears to be about right.

Presentation Number: DORMA027
Presentation Title: LLCF Effects on Emissions Control Catalyst Performance and Durability
Principal Investigator: Sreshtha Sinha Majumdar (Oak Ridge National Laboratory)

Presenter

Sreshtha Sinha Majumdar, Oak Ridge National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

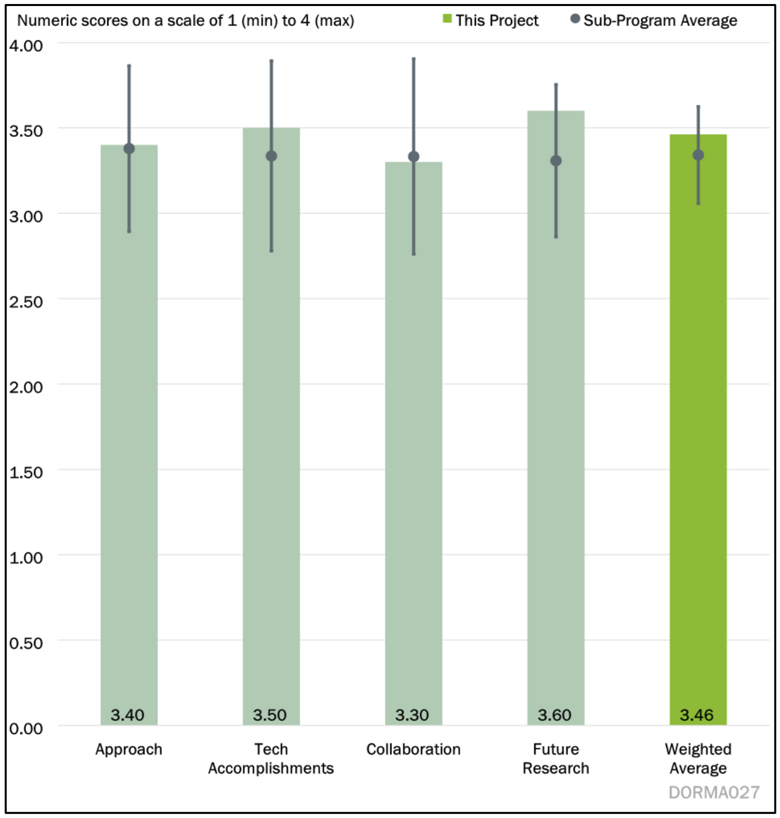

Figure 3-26 - Presentation Number: DORMA027 Presentation Title: LLCF Effects on Emissions Control Catalyst Performance and Durability Principal Investigator: Sreshtha Sinha Majumdar (Oak Ridge National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer found that this project is, to some extent, well designed but could benefit from improvement. The reviewer concurred with the team’s assessment that electrifying the rail, marine, and off-road sectors is a challenging task. However, the reviewer raised concerns about the use of high-power engines to burn ethanol and methanol fuel, noting that aldehyde emissions from alcohol have been a topic of discussion for over twenty years. The reviewer emphasized that aldehyde emissions from engines, including car and truck engines, should have been well-documented. The reviewer argued that the industry is aware of the challenges and that the key question should be about finding new DOC technology instead of characterizing light-off temperatures using the current DOC.

Reviewer 2:

The general approach taken in these studies is seen as broadly based, aimed at understanding the issues surrounding low-lifecycle-carbon fuels (LLCFs), including methanol, ethanol, and isobutanol, as replacements for other alternative fuels. These fuels were tested over a commercial palladium and platinum diesel oxidation catalyst (Pd-Pt DOC), and in the case of the two lighter alcohols, over a platinum only diesel oxidation catalyst (Pt DOC). The reviewer noted that a substantial amount of data was collected, including information on the impact of CO and the resultant NO chemistry. The reviewer also recognized that there were additional measurements that could not be discussed due to time constraints.

Reviewer 3:

The work is targeted at addressing the de-fossilization of the so-called “hard to electrify” sectors of rail, marine, and off-road vehicles by operating these vehicles on low-carbon fuels while maintaining emissions compliance.

Reviewer 4:

The reviewer noted that the project addresses the need for a better understanding of emissions when using various alcohol fuels, which can contribute to GHG reductions in the non-road sector. The utilization of two different catalyst formulations helps in understanding the impact of Pt/Pd. The project is well planned, employing established laboratory methodologies and commercial DOCs. The reviewer did acknowledge that there are always some limitations when conducting laboratory studies and translating them to real-world applications. To address this, the reviewer suggested that it might be useful to scale these experiments to engine experiments with real exhaust.

Reviewer 5:

The reviewer concluded that the work is well-documented for alcohol-containing fuels’ reactions over DOCs, the intermediate species generated, and the associated challenges. The reviewer also highlighted the importance of the next steps, such as examining other low-carbon fuels (bio-diesel, renewable diesel, dimethyl ether) and exploring alternate formulations to address intermediate species.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

Based on the milestones presented in Slide 6 and the research results presented, the reviewer determined that the team has made significant progress in this project.

Reviewer 2:

The reviewer recognized that a wealth of valuable knowledge has been obtained. Specifically, the quantification of alcohol light-offs occurring at lower temperatures than model commercial diesel fuels and the documentation of aldehydes produced were noted. The reviewer found the small amount of N_2O produced with alcohols to be very interesting. However, the reviewer pointed out that one item not discussed in the presentation was the fact that for the Pd-Pt DOC, isobutanol reacted more fully at lower temperatures than ethanol and appeared to produce much less acetaldehyde. The reviewer suggested that this could be a topic for subsequent studies, especially when considering that methanol consistently formed the smallest amount of aldehyde among the alcohols studied. From a commercial standpoint, there might be a preference for using a fuel like isobutanol over methanol, with the Pd-Pt DOC likely being favored over a Pt-only DOC.

Reviewer 3:

The reviewer noted that this project has an aggressive timeline and commended the team’s work on developing a delivery system for the formaldehyde reactant to the bench reactor. The reviewer considered this particularly impressive as it has been a challenge in many research laboratories. The solution devised by this team and its successful implementation is stable and capable of reaching high concentrations. The reviewer found the results to be interesting, as they showed that the PGM content did not impact the reactivity trends of the alcohols or aldehydes. Additionally, the study revealed that methanol oxidation resulted in unfortunate byproducts in the form of formaldehyde, and ethanol formed acetaldehyde. These aldehydes were found to be less reactive than the alcohols, making remediation more challenging. The reviewer acknowledged that there are still barriers to overcome, which will be addressed in future work.

Reviewer 4:

The reviewer commended the project for providing a good fundamental understanding of intermediate aldehyde species' formation and their reactivity on commercial catalysts. The choice of two commercial catalysts, Pd/Pt and Pt-only, was noted as providing a valuable directional understanding.

Reviewer 5:

The reviewer stated that the work on alcohol-containing fuels is well executed and suggested that a similar process should be followed for other LLCFs.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer noted that the research work has been carried out at Oak Ridge National Laboratory. Caterpillar's contribution to this project is primarily in-kind support and industry input related to test cycles, industry opinions about ethanol/methanol fuel, and supplying DOCs, among other aspects. However, the reviewer found that there appears to be no significant technical contribution from Caterpillar. The reviewer suggested that the principal investigator may want to provide more detailed information about the technical contribution from Caterpillar.

Reviewer 2:

As mentioned in the Response to Comments from Reviewers, the reviewer pointed out that the inclusion of a catalyst supplier could be beneficial. Specifically, obtaining DOC catalysts from a catalyst supplier could enhance the project. Informal discussions with such a supplier could offer valuable insights. The reviewer also suggested that other researchers at universities and national laboratories who are working on aldehyde reactions might be potential collaborators, either at some level or more directly, particularly when transitioning from alcohols to CO_2 and H_2O.

Reviewer 3:

The reviewer found that clear roles for the partners have been established, with Caterpillar actively providing input and guidance.

Reviewer 4:

The reviewer commended Caterpillar for its industry guidance on aging conditions and for providing catalysts.

Reviewer 5:

The reviewer raised the question of whether having a catalyst formulation supplier as part of the project team would be useful.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer considered the proposed future work to identify and evaluate alternate catalyst formulations to be excellent, especially given the challenging nature of the task. The reviewer suggested that the team should focus on this topic in their future work.

Reviewer 2:

The reviewer emphasized that the future research topics are essential, particularly in the context of finding better catalysts for converting aldehydes at low temperatures and exploring other alternative LLCFs. The reviewer also raised the possibility of considering an additive to a Pd-Pt DOC that could potentially lead to a fuller oxidation of the reaction, inhibiting aldehyde formation. The reviewer noted that this option was not mentioned among the choices presented. The reviewer inquired about the impact of NO in the area, as it was mentioned that carbon monoxide (CO) reaction could slow alcohol reaction, but the reviewer did not recall a study of the impact of NO.

Reviewer 3:

The reviewer recognized that as part of this year's technical accomplishments, it has been identified that alcohol fuels, both methanol and ethanol, lead to aldehyde products of combustion, which are challenging to remediate. The planned future work addresses the key barrier of low-temperature aldehyde oxidation. Additionally, the future work extends the fuel matrix to include additional renewable fuels.

Reviewer 4:

The reviewer suggested discussing the results of the NO–NO_2 reactivity study, which were not shown, in the next meeting. The reviewer also recommended including an examination of the impact of sulfur and other chemical aging. Finally, the reviewer suggested including some real engine work with full-size catalysts.

Reviewer 5:

The reviewer concluded that looking at other LLCFs and exploring different DOC formulations to address intermediate species are the right next steps.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer found that this project is closely relevant to future off-road engines, which support the overall VTO subprogram objectives.

Reviewer 2:

The reviewer observed that the research on LLCFs that this project conducts clearly meets the needs of our society to cost-effectively meet emission standards and lower GHG emissions at the same time, which is a core principle in the DORMA area.

Reviewer 3:

The reviewer stated that this project is extremely relevant to DOE VTO program objectives.

Reviewer 4:

The reviewer pointed out that oxygenated fuels are promising candidates for GHG reductions, and it is crucial to understand the side emission issues associated with them.

Reviewer 5:

The reviewer considered this to be a very timely topic and encouraged the project to continue.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer noted that ORNL has sufficient facility and resources to achieve the milestones in a timely fashion.

Reviewer 2:

The reviewer found that the experimental tool resources needed and available are well-covered for this project at ORNL.

Reviewer 3:

The reviewer suggested that while $400,000 per year seems sufficient, it may be just barely enough for this work. The reviewer encouraged considering additional funding if possible.

Reviewer 4:

The reviewer acknowledged that the resource allocation is currently good but emphasized that it will benefit from engine testing.

Reviewer 5:

As mentioned in previous comments, the reviewer reiterated the idea that perhaps the inclusion of a catalyst formulation supplier would be useful.

Presentation Number: DORMA028
Presentation Title: Comprehensive Integrated Simulation Methodology for Enabling Near-Zero Emission Heavy-Duty Vehicles
Principal Investigator: Andrea Strzelec (University of Wisconsin-Madison)

Presenter

Andrea Strzelec, University of Wisconsin-Madison

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

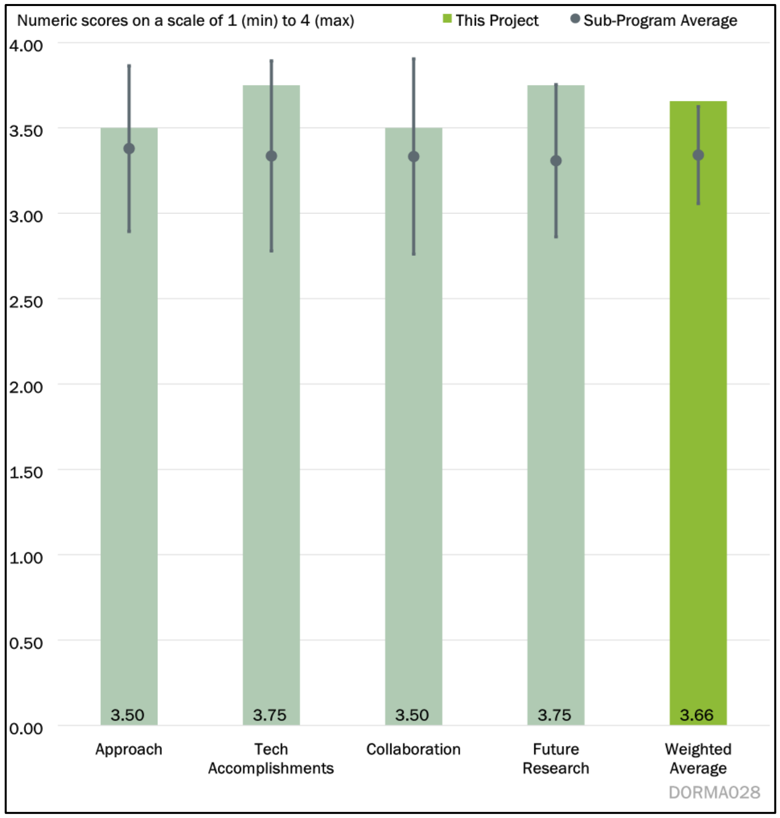

Figure 3-27 - Presentation Number: DORMA028 Presentation Title: Comprehensive Integrated Simulation Methodology for Enabling Near-Zero Emission Heavy-Duty Vehicles Principal Investigator: Andrea Strzelec (University of Wisconsin-Madison)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The project is well-designed to develop an integrated simulation platform for designing exhaust system architectures and control strategies to meet future ultra-low NO_x emissions standards throughout a vehicle's full useful life. The reviewer recognized that this model could potentially assist OEMs in reducing the time and costs associated with deploying new emission reduction technologies.

Reviewer 2:

The reviewer found that the overall project is well laid out, and everything appears to be on schedule. The reviewer also noted that all collaborators are actively contributing.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer stated that the project has made significant progress, having accomplished approximately 40% of this 3-year project. The GT-SUITE stochastic reactor model (GT-SRM), GT engine, and GT-multi-cylinder SRM models have been developed and validated. Additionally, the aftertreatment components have been calibrated for both steady and transient conditions, which are crucial for cycle and cold-start simulations.

Reviewer 2:

The reviewer noted that the overall project is making good progress and encouraged the team to continue their good work.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer expressed appreciation for the strong collaboration involving a national laboratory, a university, automotive transmission companies, an automotive consulting company, and an oil company. The collaborative efforts seem well-structured and diversified, bringing together expertise from various sectors. Furthermore, the reviewer acknowledged the principal investigator's efforts to work with the Coordinating Research Council (CRC) to expand the project's scope to cover fuel effects on aftertreatment systems.

Reviewer 2:

The reviewer commended the project for its well-balanced mix of collaborators, including an engine OEM, a catalyst supplier, government laboratory utilization, two universities, FEV Test Systems for testing, a fuel company, and the CRC. This diverse set of collaborators is expected to provide the project with valuable resources and expertise to overcome potential challenges. The reviewer also expressed appreciation for the CRC's offer to provide additional fuels for testing.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer stated that the future research is well planned.

Reviewer 2:

The reviewer highlighted the significance of investigating SCR catalyst aging, emphasizing its importance and the need for validation. However, the reviewer noted a potential gap in the project's plans, as there does not seem to be any specific provisions for modeling NH_3 storage or addressing the potential for urea deposits. The reviewer raised a question about whether these aspects would be addressed in the future work.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer expressed that this work is absolutely relevant to DOE objectives, particularly in the context of reducing criteria emissions, which are crucial for achieving clean and sustainable transportation in the future.

Reviewer 2:

The reviewer affirmed that the improved models resulting from this project will provide valuable assistance to engine OEMs in optimizing their systems for improved fuel economy. The reviewer also noted that these models are expected to eventually be incorporated into GT-POWER simulation model, making them accessible for all users. The reviewer praised the involvement of the CRC in the project and highlighted its potential to encourage testing with renewable diesel fuel and possibly other low net carbon fuels. The reviewer recognized that this aligns with the VTO objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that overall, the team has the most resources to conduct the relevant research.

Reviewer 2:

The reviewer expressed that it appears good progress is being made with the resources provided.

Presentation Number: DORMA029
Presentation Title: Fast Simulation of Real Driving Emissions from Heavy-duty Diesel Vehicle Integrated with Advanced Aftertreatment System
Principal Investigator: Hailin Li (West Virginia University)

Presenter

Hailin Li, West Virginia University

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

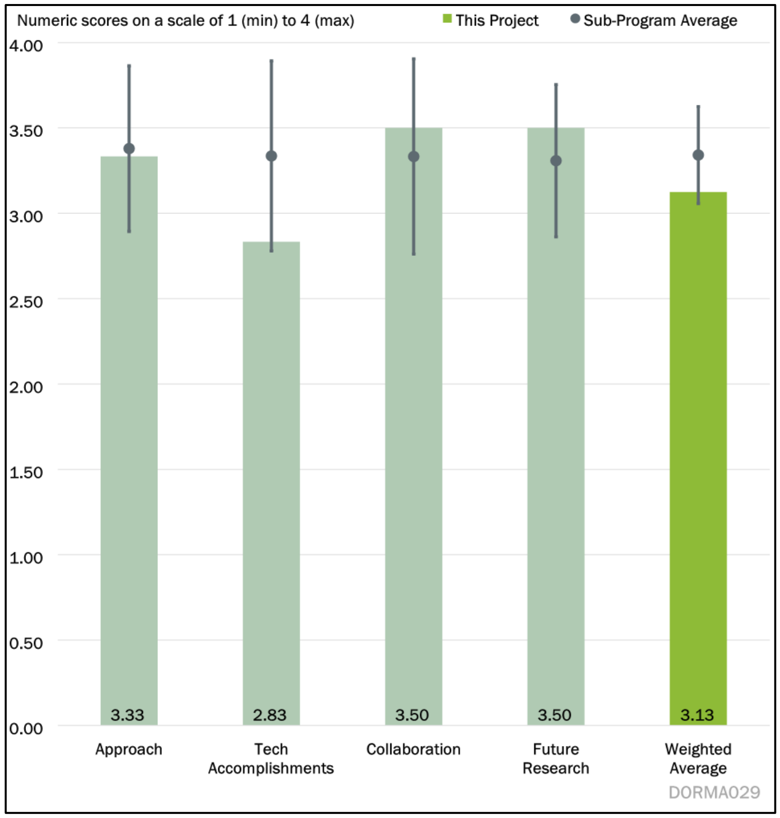

Figure 3-28 - Presentation Number: DORMA029 Presentation Title: Fast Simulation of Real Driving Emissions from Heavy-duty Diesel Vehicle Integrated with Advanced Aftertreatment System Principal Investigator: Hailin Li (West Virginia University)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer praised the outstanding approach taken in this project, which encompasses a wide range of simulation tools, from 1D to 3D, detailed and map-based engine models, to complete vehicle models. The fact that all these models will be validated against experimental data was seen as a substantial enhancement to model fidelity.

Reviewer 2:

The reviewer found the project to be well-designed, focusing on developing and validating simulation tools that enable the virtual coupling of engine combustion with aftertreatment systems. The reviewer acknowledged the potential significance of these simulation tools for both OEMs and the research community. These tools can be used to simulate real driving emissions from HD diesel trucks, optimize HD diesel engines and aftertreatment systems for near-zero emissions, develop pathways to achieve super-low NO_x emissions, and explore technologies to minimize CO_2 emissions.

Reviewer 3:

The reviewer mentioned some challenges in the project, particularly related to the contract's duration and delays due to issues with the West Virginia University (WVU) engine laboratory. While the reviewer appreciated the efforts to find an alternative test laboratory and WVU's additional funding to cover increased test costs, they anticipated that testing at a third party could be more challenging to manage, potentially extending the timeline for data collection. The reviewer raised a concern about the absence of plans to model urea storage in the SCR catalyst, highlighting its importance for achieving faster NO_x conversion at low temperatures. Additionally, the reviewer pointed out that urea deposits can occur over time and suggested that it might be beneficial to discuss or consider modeling urea deposits, even if a good model is not available at present.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer noted significant progress on the modeling side, with advancements in 1D, 3D, and aftertreatment models. However, the lack of progress on engine testing was a concern for the reviewer, as it could noticeably impact the overall project progress.

Reviewer 2:

The reviewer reported that the project had progressed well, accomplishing about 70% of the year-one project. Key accomplishments included the validation of CFD and 1D models for combustion simulation, the development and integration of aftertreatment components models with GT, and the development of a 1D urea model. The delay in engine experimental research was attributed to the temporary closure of the WVU engine laboratory. A remedy plan was in place to catch up, and a 12-month no-cost extension had been approved by DOE, which was expected to help keep the project on schedule.

Reviewer 3:

The reviewer recognized that the project had experienced delays in obtaining a signed contract and faced issues with the WVU engine laboratory, resulting in a delay in engine testing. While model development seemed to be on track, the reviewer stressed the importance of generating engine data for validation. Additionally, there was a concern about obtaining the necessary information on the SCR catalyst to properly tune the model.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer expressed that it seems that all key partners are contributing to the progress of the project.

Reviewer 2:

The reviewer noted strong collaboration with national laboratories, research institutes, automotive consulting companies, and energy companies.

Reviewer 3:

The reviewer mentioned that while all the correct partners have been identified, it is challenging to judge the extent of their contributions, particularly since the project is behind schedule.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer stated that the future research is very well defined and expressed eagerness to see more progress on machine learning in the following year.

Reviewer 2:

The reviewer commended the team’s plan to catch up on experimental work and acknowledged the well-planned aspects of the project. This included CFD, algorithm development, criteria for achieving adaptive aftertreatment system simulation under transient operation, simulating real-world driving emissions, and using machine learning for aftertreatment system simulation and emissions research.

Reviewer 3:

The reviewer found the future work related to developing adaptive aftertreatment system simulation over transient operation to be interesting. They also recognized the value of exploring a Machine Learning-based framework for adaptive system simulation in enhancing the existing knowledge base for engine modeling.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer stated that with a range of simulation tools from 1D to 3D, covering everything from the engine to the vehicle, the project should support the overall VTO program objectives.

Reviewer 2:

The reviewer noted that the project is aligned with overall DOE objectives for clean, efficient, and sustainable transportation.

Reviewer 3:

The reviewer also recognized that improving the complete engine/aftertreatment system to meet future emission regulations with reduced fuel consumption and lower precious metal costs aligns with the VTO goals.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer expressed confidence that the project should have enough funding to complete the project.

Reviewer 2:

The reviewer found the resources to be adequate for the proposed research and expressed hope that WVU could reopen the engine laboratory to facilitate the accomplishment of the project.

Reviewer 3:

The reviewer believed that funding should be sufficient, especially given that WVU is covering the additional engine test cell costs for performing the engine tests at an outside laboratory.

Presentation Number: DORMA030
Presentation Title: Opposed-Piston 2-Stroke Hybrid Commercial Vehicle System
Principal Investigator: Fabien Redon (Achates Power)

Presenter

Ming Huo, Achates Power

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 67% of reviewers felt that the resources were sufficient, 33% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

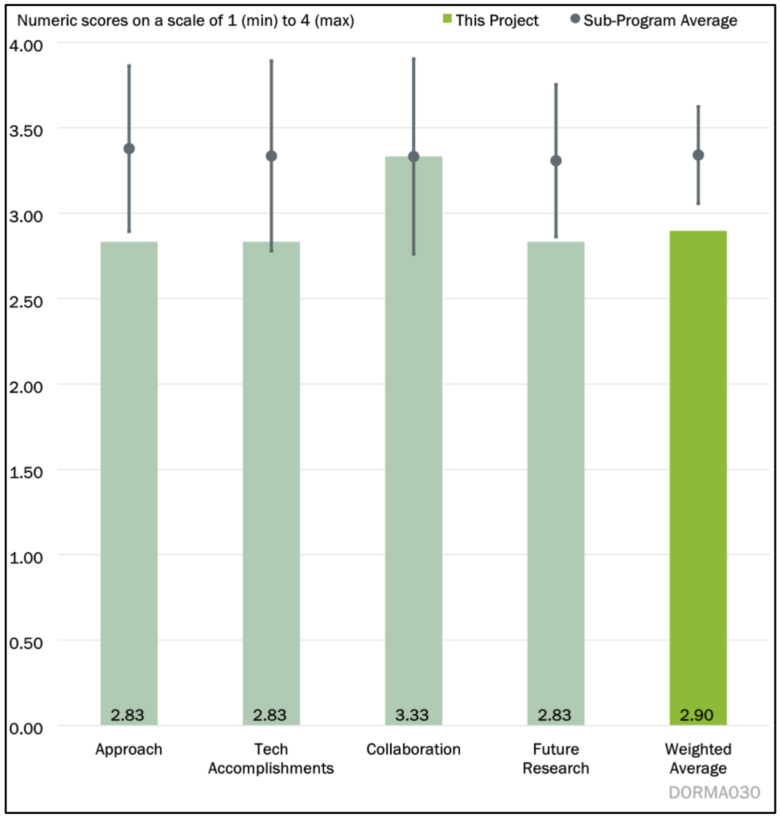

Figure 3-29 - Presentation Number: DORMA030 Presentation Title: Opposed-Piston 2-Stroke Hybrid Commercial Vehicle System Principal Investigator: Fabien Redon (Achates Power)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer stated that while the adaption and implementation of a hybrid system in medium- and HD vehicles is generally interesting, it is not clear whether there is a compelling need for the opposed piston, two stroke (OP2S) architecture. They pointed out that ultra-low emissions require aftertreatment in any case and have been demonstrated with conventional configurations. The reviewer also raised concerns about the use of H_2 combustion and cited past experiences with two-stroke commercial methanol engines.

Reviewer 2:

The reviewer acknowledged that the project combines simulations and experiments to optimize engine/emission performance and sees the potential for finding synergistic benefits in combining opposed piston and hybridization. They also appreciated the inclusion of H_2 as a new fuel, given industry efforts to evaluate H_2 combustion. However, the reviewer cautioned that the current approach appears to aim for too many objectives simultaneously, including achieving low NO_x, improving efficiency through hybridization, and evaluating H_2, potentially stretching the project’s focus.

Reviewer 3:

The reviewer raised questions about the approach for the dual ignition mode combustion strategy and the machine learning approach, seeking more clarity on how these approaches will help achieve the project’s overall goals.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer noted that while there is evidence of progress in modeling and seeking improvements in diesel combustion, the report lacks clarity on any new discoveries that have emerged. They mentioned that the development of hybrid configuration models is interesting but should be compared to prior work. The reviewer also suggested that the advantages of the OP2S architecture are not distinct at this stage. However, they expressed interest in the upcoming H_2 testing.

Reviewer 2:

The reviewer stated that data collected from opposed piston engines has been used for model calibration and supports the engine's ability to meet ultra-low NO_x requirements with a conventional aftertreatment. This represents a significant change compared to conventional diesel engines, which usually require additional close-coupled SCR. The simulations demonstrated the potential for improvements through hybridization and combustion enhancements, as well as the feasibility of H_2 combustion. However, the reviewer wished there was more experimental data available to support the claims already made.

Reviewer 3:

The reviewer found the progress toward the project plan to be good regarding the modeling and calibration of the engine but noted that the report lacked details on the status of testing with H_2.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer commented that the team members are highly qualified and have collaborative roles.

Reviewer 2:

The reviewer noted that there appears to be good collaboration with academia, national laboratories, and another OEM. However, it was unclear how much or what work is being done by Isuzu.

Reviewer 3:

The reviewer mentioned good coordination across the teams but found it unclear what role Argonne National Laboratory has in the project. While Argonne is not listed as a partner, testing at Argonne was noted on Slide 16.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer expressed an interest in seeing evidence that the OP2S engine would have a higher thermal efficiency of 20% or more and inherently lower NO_x emissions compared to reciprocating engines.

Reviewer 2:

The reviewer appreciated the shift in focus from simulations to engine testing. However, the reviewer mentioned that it might have been better to concentrate on either hybridization or H_2 instead of pursuing both simultaneously.

Reviewer 3:

The reviewer noted that while the future research plan includes clear deliverables, the connection between these plans, specific targets, and the ultimate project goals is not clearly presented.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer expressed concerns about the relevance of the project, suggesting that the benefits are not conspicuous and likely not significant. The reviewer highlighted that the assessment of hybrid electric vehicles is the most relevant area.

Reviewer 2:

The reviewer noted that meeting low NO_x and GHG reductions simultaneously for HD trucks is a critical focus in the coming years.

Reviewer 3:

The reviewer mentioned that the project does support the overall VTO subprogram objectives but noted the absence of specific references to the relevance of the project to the decarbonization blueprint or specific VTO goals. Instead, the relevance is primarily focused on market barriers.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commended Achates for its success in leveraging funds and finding cost-sharing opportunities.

Reviewer 2:

The reviewer expressed concerns about the sufficiency of resources based on the project’s scope, which includes improving engine efficiency, considering hybridization, and H_2 internal combustion engines.

Reviewer 3:

The reviewer believed that the resources appear to be sufficient for the proposed work.

Presentation Number: DORMA031
Presentation Title: Dynamic Skip Fire (DSF) on a Heavy-Duty Natural Gas Engine
Principal Investigator: Jay Shah (Cummins)

Presenter

Jay Shah, Cummins

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 25% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

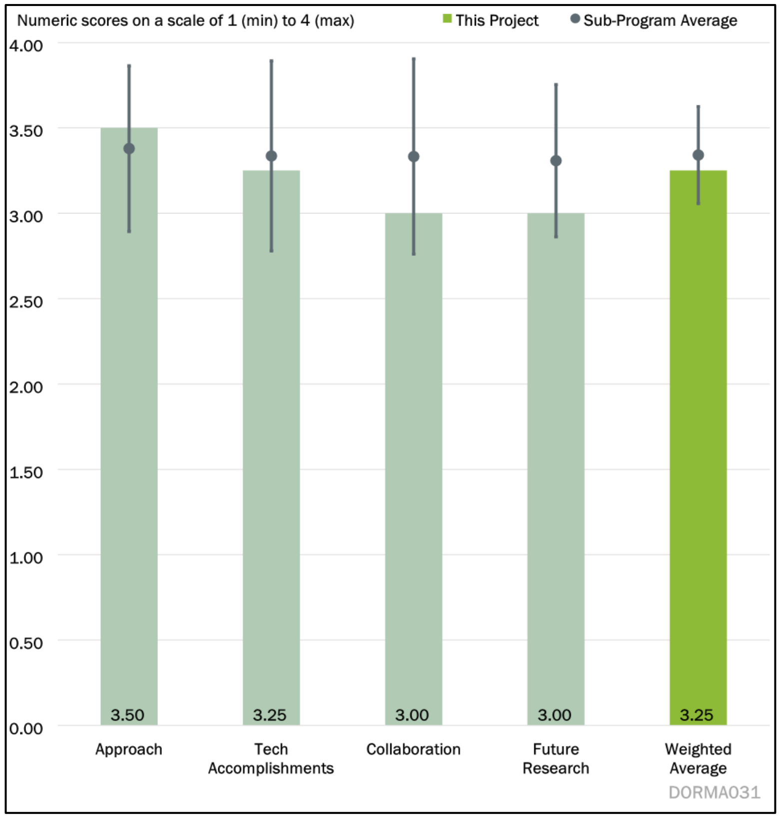

Figure 3-30 - Presentation Number: DORMA031 Presentation Title: Dynamic Skip Fire (DSF) on a Heavy-Duty Natural Gas Engine Principal Investigator: Jay Shah (Cummins)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer stated that dynamic skip fire (DSF) is an effective approach to improving part-load efficiency, which is crucial for achieving near-diesel efficiency in natural gas (NG) engines. They also noted that the project is addressing the challenges related to developing a fully functioning DSF system with suitable emission controls and noise, vibration, and harshness considerations.

Reviewer 2:

The reviewer praised the project's organization and the distinct roles of each team member. The project involves applying a proven valve deactivation strategy used in smaller engines to a HD NG engine at Cummins. This adaptation requires hardware development, system modeling, integration, and calibration.

Reviewer 3:

The reviewer mentioned that many technical barriers related to implementing DSF have been addressed by developing an advanced NG engine platform with a different valve train design, making it more suitable for DSF implementation.

Reviewer 4:

At a high level, the approach is considered appropriately defined. The reviewer appreciated the incorporation of a workplan in the report. However, the reviewer expressed concerns about the project's timing, noting that it has already been extended by seven months since its initiation. The timeline and workplan appear to be behind schedule. The material required date for engine parts is expected in August 2023, which implies that completing the engine build and rig testing by the end of Q3 2023 could be challenging. The reviewer recommended developing detailed plans to ensure alignment between engine dynamometer calibration and vehicle integration activities. Using start carts/rigs and hardware-in-the-loop testing to develop and validate DSF controls before engine dynamometer testing was also suggested.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer expressed that progress is evident in system simulation and the design and start of component build.

Reviewer 2:

The completion of all project milestones for budget period 1 was considered a success, and the involvement of Jacobs Vehicle Systems to help with CDA hardware design was noted as beneficial.

Reviewer 3:

The project was commended for addressing critical barriers related to transient air-fuel ratio control and oil consumption through design changes and improved control strategies. The reviewer was particularly impressed that the risk of oil consumption was mitigated by changes in piston ring design and recharge strategy. However, the results shared in the presentation did not provide substantial information about engine vibration characteristics. The reviewer expressed hope that future updates would shed more light on this aspect.

Reviewer 4:

The reviewer noted that, relative to 2022, progress in the project seems limited. They observed that several slides and results appeared to be a carryover from the previous year, which might contribute to the impression of slow progress. The reviewer suggested that including additional details from CDA hardware design, control development, and DSF simulations in future updates would aid in assessing project accomplishments.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer mentioned that the project team consists of pioneers and leaders in DSF and CDA, with complementary roles.

Reviewer 2:

The reviewer considered this to be a good teaming arrangement to achieve the project’s technical goals. However, the reviewer expressed concerns about the absence of national laboratory and academic partners. They suggested that the lack of academic partners might limit the amount of information that the project could release to the public through journal publications and missed an opportunity to help develop the next generation of scientists and engineers in the field.

Reviewer 3:

The project’s collaboration with Cummins was noted as excellent by the reviewer.

Reviewer 4:

The reviewer pointed out some concerns about the roles and contributions of specific project partners. For example, they mentioned that Tula Technology, responsible for DSF controls integration, and Jacobs Vehicle Systems, responsible for CDA and engine brake hardware design, lacked clear definitions of their current and future contributions. The reviewer suggested that, in future reviews, it might be beneficial to define the roles and responsibilities of all project partners in greater detail.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The project's plan to proceed through full engine tests and potentially chassis/vehicle tests was considered solid by the reviewer. However, there was some uncertainty during the presentation about the commercialization of DSF for NG engines. The reviewer hoped that the system could be proven to be robust and cost-effective for commercial NG engines, helping to close the efficiency gap with diesel engines.

Reviewer 2:

The research plan for the project was considered good and appeared to be sufficient to achieve the project's objectives. However, the reviewer expressed disappointment that there was not a production feasibility analysis included in the project to understand the additional cost of producing an engine with the Tula controlled dynamic CDA technology compared to the fuel economy benefit.

Reviewer 3:

The reviewer expressed interest in future results related to tailpipe-out NO_x during transient operation, pumping loss characteristics, and associated CO_2 benefits.

Reviewer 4:

The reviewer noted that while the next steps for the next year were clearly defined, the description of the tasks was somewhat limited. In particular, they suggested that the tasks for emissions calibration and validation could be better defined.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer emphasized that natural gas, especially in conjunction with renewable natural gas (RNG), serves as an effective CO_2 reduction pathway already widely implemented. Furthermore, they pointed out that improved engine efficiency achieved through this project offers the potential for additional carbon reduction and the expansion of RNG supply.

Reviewer 2:

In the reviewer's assessment, the project's primary objective is to enhance engine efficiency by utilizing natural gas as a lower-carbon alternative to traditional diesel fuel.

Reviewer 3:

The reviewer believed this approach aligns with DOE's objectives, which include reducing CO_2 emissions and promoting the use of domestic fuels for transportation.

Reviewer 4:

The reviewer also observed that the project is in harmony with DOE's overarching goal of enhancing vehicle efficiency and reducing GHG emissions through advancements in engine efficiency and the adoption of alternative and low-carbon fuels.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

According to the reviewer, the progress suggested that the resources are adequate so far.

Reviewer 2:

The reviewer said that the project resources appeared to be sufficient to achieve the objectives of the project.

Reviewer 3:

The reviewer believed that the funding is sufficient for the proposed work.

Presentation Number: DORMA032
Presentation Title: High Efficiency, Ultra Low Emissions Heavy-Duty 10L Natural Gas Engine Project
Principal Investigator: Tim Lutz (Cummins)

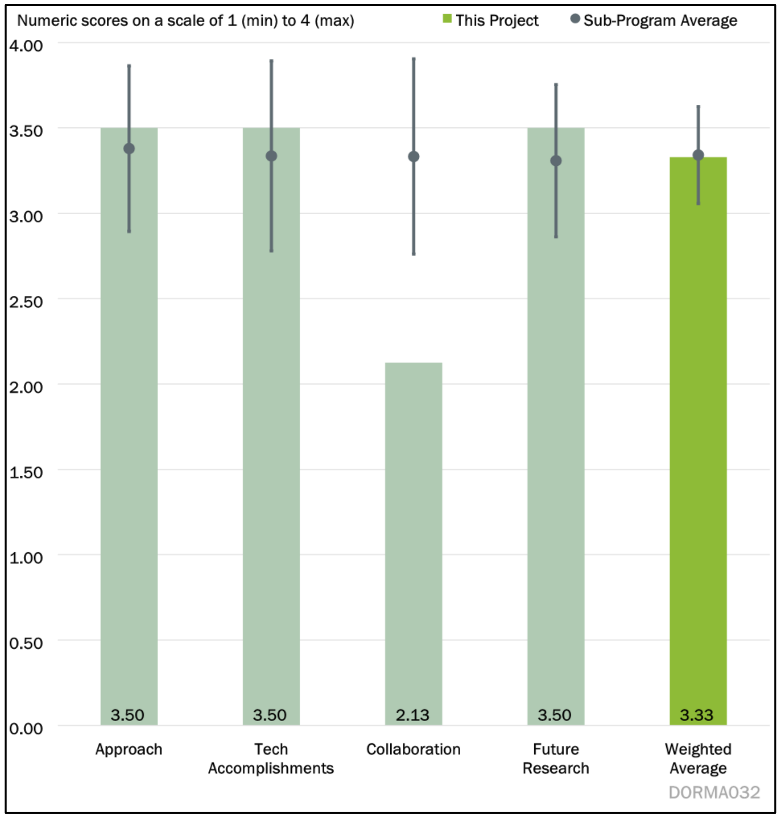

Figure 3-31 - Presentation Number: DORMA032 Presentation Title: High Efficiency, Ultra Low Emissions Heavy-Duty 10L Natural Gas Engine Project Principal Investigator: Tim Lutz (Cummins)

Presenter

Tim Lutz, Cummins

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer found that the project was well-focused on improving engine efficiency, recognizing it as one of the key hindrances for expanded use of natural gas (NG) in freight trucks. The path to high efficiency appeared to be very solid, characterized by good engineering with moderate risk. Higher-risk technology breakthroughs or more stretching innovations, such as the advanced materials mentioned in the slides, were noted but lacked sufficient detail.

Reviewer 2:

The reviewer assessed the approach as sound and appropriate for development. The use of CFD and modeling as the initial step was acknowledged as an industry standard and a commendable approach before proceeding to test a metal engine.

Reviewer 3:

The reviewer observed that the project was well-organized and aimed at developing and implementing next-generation technologies for natural gas in large engines. The approach involved analyzing various known available technologies demonstrated to increase efficiency and reduce emissions in other applications. The reviewer also noted the use of a modeling approach to determine an experimental platform for testing. The main criticism highlighted was related to the analysis, which indicated that EGR might not be necessary to meet efficiency targets, but there was a significant amount of uncertainty regarding the modeling results, particularly in exhaust temperature predictions and knock prediction. The reviewer understood the hesitation towards EGR due to its potential design compromises in terms of durability, transients, and air handling. However, the reviewer expressed the view that ruling out EGR based on modeling results appeared to be a missed opportunity. At the very least, having the option to use EGR in the first generation of hardware could have helped reduce uncertainty and enhance design tools for future applications. The reviewer also suggested that providing a more detailed description of the baseline technology in terms of efficiency and compression ratio relative to the engine being developed would have been beneficial.

Reviewer 4:

The reviewer pointed out one of the primary issues with stoichiometric NG engines, which is maintaining flame speed at low loads and managing exhaust temperatures at high loads. The proposed approach of using a pent-roof head for tumble while minimizing swirl was seen as a potential solution to improve NG combustion speed and mitigate knock. The switchable Miller late intake valve closing approach was expected to aid in increasing temperatures at low load, thus enhancing the effectiveness of the three-way catalyst under low load conditions. The reviewer acknowledged some uncertainty in the model predictions, particularly in temperature and the necessity of EGR and manifold cooling. Additionally, there was some uncertainty regarding knock prediction.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer noted that the project, in its relatively early stage, is on a solid path, utilizing modeling and simulation to guide engine improvements and transition towards hardware development. The reviewer expressed a need for more detailed information regarding the contributions of materials to the project's advancements. Furthermore, the reviewer observed a lack of comparison and benchmarking against existing technology and efficiency in the presentation, suggesting that incorporating public data from previous Cummins engines and competitor data would provide a clearer assessment of progress.

Reviewer 2:

In the reviewer's evaluation, the project was found to be on track. The principal investigator acknowledged the challenge of predicting knock, and the reviewer recommended additional work to refine exhaust temperatures before proceeding to engine testing.

Reviewer 3:

The reviewer commended the good progress achieved at this early stage of the project. The modeling results had effectively guided design decisions for the first generation of hardware.

Reviewer 4:

The reviewer, considering the project's first year, found the progress to be promising. The reviewer noted that the project had established the design landscape and defined the overall approach, with simulation work completed and predictions aligning with the project's target goals.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The absence of formal partners within the team was noted by the reviewer.

Reviewer 2:

In the reviewer's assessment, all project work is conducted exclusively within Cummins, making it appropriate to include a "N/A" option for this section due to the singular entity involved. The reviewer emphasized that the internal teams within Cummins appear to be collaborating effectively and expressed a reluctance to assign a low rating solely due to the lack of external partners.

Reviewer 3:

The reviewer observed a lack of collaboration within the project, as Cummins stands as the sole participant. While recognizing that Cummins may possess the technical capabilities required to achieve the project goals independently, the reviewer stressed the potential benefits of including academic partners or national laboratories. Such partnerships would enhance the likelihood of disseminating technology development through journal or conference papers, thereby contributing to the public domain. Additionally, partnering with universities could provide funding for training the next generation of scientists and engineers in the field.

Reviewer 4:

The reviewer acknowledged the challenge of rating this criterion, given the absence of external partners in the project. Cummins remains the sole participant. The reviewer suggested that coordinating work with a university and/or a national laboratory, or even involving a supplier, could have been beneficial. This, in the reviewer's opinion, might have provided Cummins with an opportunity to leverage their ongoing collaborations with universities and national laboratories to investigate fundamental issues related to NG engine knock, thereby helping validate simulation models.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer stated that the description of the path to project completion and success is clear and comprehensive, with an understanding of the associated uncertainties and challenges.

Reviewer 2:

The reviewer acknowledged that the project had correctly identified the engine testing requirements. However, the reviewer suggested that including additional work on the total cost of ownership and conducting a life-cycle analysis would be a valuable addition.

Reviewer 3:

The proposed future work aligns with the well-organized approach outlined in the project, including a demonstration of the first engine's performance. The reviewer viewed the absence of cooled EGR capabilities in the engine's design as a missed opportunity, given the significant uncertainties in exhaust temperature and knock modeling. The reviewer noted that incorporating cooled EGR into the engine's design could have provided valuable performance metrics and informed modeling approaches to reduce modeling uncertainty.

Reviewer 4:

The reviewer commended the decision to build and test an engine as a means of validating the extensive simulation work conducted thus far. However, a slight drawback mentioned by the reviewer was the inability to modify Engine #1 for EGR if it were to become necessary. The reviewer highlighted the potential issue of being unable to rectify any errors if the initial prediction that "no EGR is needed" turns out to be incorrect until the construction of Engine #2.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer said that the utilization of NG, particularly RNG, represents a clear and feasible approach to reducing CO_2 emissions in this sector. The reviewer remarked that these fuels are cost-competitive but could benefit from enhanced engine efficiency, a fact well-documented by DOE and the industry. According to the reviewer, the project’s path is highly relevant to national energy security and promoting affordable freight movement.

Reviewer 2:

The reviewer expressed the view that diesel engines are expected to remain in use for the foreseeable future, making it imperative to focus on decarbonizing them rather than neglecting the issue.

Reviewer 3:

The reviewer affirmed that the project aligns with program goals, particularly the objective of increasing engine efficiency and transitioning towards lower carbon fuels while maintaining or improving emissions performance.

Reviewer 4:

The reviewer observed that this project supports DORMA by offering a pathway to enhance the efficiency and emissions performance of NG HD engines. The reviewer articulated that in sectors where electrification is challenging, NG engines are seen as a viable means for decarbonization and improving air quality. Additionally, the reviewer pointed out that if RNG becomes more readily available at scale, there could be added benefits to this approach.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that the project funding appears adequate and is a suitable investment by DOE and Cummins cost-share.

Reviewer 2:

The reviewer pointed out that DOE should allocate more resources to the hard-to-decarbonize sectors and ICE technology. The reviewer expressed the belief that the idea of electrifying everything is not entirely true, and the timeline for such a transition is too distant. The reviewer stressed the continued need for ICE technology. In the reviewer’s opinion, it is better to focus on projects like this one that seek ways to lower the GHG emissions of ICE technology rather than ignoring it and relying solely on electrification for all applications.

Reviewer 3:

The reviewer remarked that the resources for the project appear to be sufficient, as most of the project milestones are on track.

Reviewer 4:

The reviewer also stated that the resources seem adequate to achieve the goals of this project. The reviewer acknowledged that Cummins already possesses an internal infrastructure for designing and building NG engines. According to the reviewer, this project pushes Cummins out of its comfort zone somewhat, particularly with elements like the pent roof head and switchable Miller late intake valve closing. The reviewer noted that resources would be allocated to these innovative aspects. Overall, the reviewer saw this as a beneficial combination of exploring new ideas while building upon existing experience and capacity.

Presentation Number: DORMA033
Presentation Title: High Pressure Fast Response Direct Injection System for Liquified Gas Fuels Use in Light-Duty Engines
Principal Investigator: William de Ojeda (WM International Engineering)

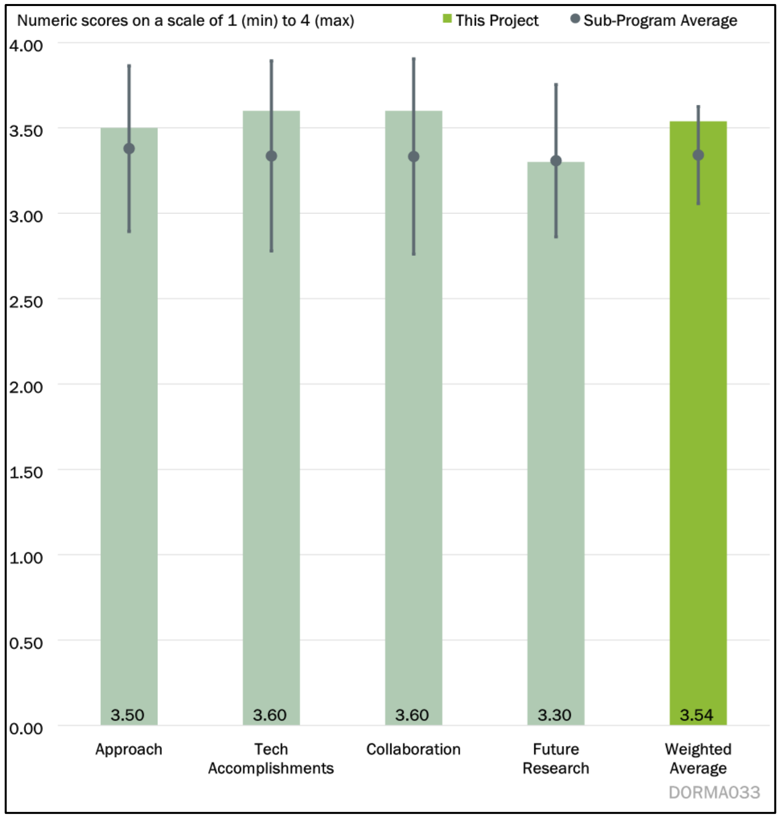

Figure 3-32 - Presentation Number: DORMA033 Presentation Title: High Pressure Fast Response Direct Injection System for Liquified Gas Fuels Use in Light-Duty Engines Principal Investigator: William de Ojeda (WM International Engineering)

Presenter

William de Ojeda, WM International Engineering

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

80% of reviewers felt that the project was relevant to current DOE objectives, 20% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer noted that the project's targets are very specific and clear. Detailed barriers are presented, and the overall approach is considered sound. However, the reviewer questioned the overall impact of this fuel strategy in achieving lower CO_2 emissions in light-duty vehicles (LDVs). Since this is the first year of review for the project, the reviewer recommended providing some background and explanation of the overall strategy for CO_2 reduction. The reviewer suggested discussing whether this strategy is relevant for the U.S. market or the European Union, where compression ignition LDVs are more prevalent. The reviewer also pointed out the existence of prior literature on this approach and recommended that the presentation at least mention some of those efforts.

Reviewer 2:

The reviewer assessed the approach being taken to address the challenges with a liquefied gaseous fuel, noting its strengths and weaknesses. The reviewer considered the fuel system design as the strongest element of the approach, with the team making excellent progress in the areas of pumping, fuel injection, and control systems. However, the reviewer expressed some skepticism about the approach of mixing propane and DME, as these fuels have distinct ignition characteristics. The reviewer found the motivation behind this strategy to be lacking clarity and suggested a more comprehensive explanation of the rationale for this choice.

Reviewer 3:

The reviewer found that the project is well-designed to address key barriers related to injector wear, performance comparison to diesel injectors, and unstable combustion. The development of the injector test rig was identified as an important project update for the first budget period.

Reviewer 4:

The reviewer noted that the technical approach for the project is well defined and meticulously tracked. The reviewer appreciated the clear identification of technical barriers and the well-defined project tasks to address these barriers. The reviewer highlighted the clarity of the description of the overall approach, indicating that the project team has a good understanding of system-level interactions between different components and sub-systems, including the fuel system, combustion strategies, control requirements, and engine/vehicle functional objectives. The reviewer acknowledged that tasks have been designed to address relevant technical challenges, and the responsibilities of the project partners are clearly defined for both testing and modeling efforts.

Reviewer 5:

The reviewer commended the project team for thoroughly exploring both the combustion process and fuel injection system behavior in liquefied gas engines. The approach was seen as sound, given the interrelated nature of these aspects. The reviewer also noted that the project was well presented, and the challenges and barriers were very well explained.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The project has made good progress on developing models and the build-up of the experimental system, including the fuel pump, among other components.

Reviewer 2:

The reviewer noted that the project is making good progress in developing a pumping and fuel delivery system compatible with liquefied gases, specifically propane and DME. The project team has successfully identified and addressed several key barriers, including maintaining the fuel in a liquid form during the pumping process. They have also identified additional barriers related to controlling the rail pressure with a compressible fuel.

Reviewer 3:

During budget period 1, the project accomplished a significant number of activities. The simulations developed appear to align well with test data, defining the engine requirements for developing an injector system and high-pressure fuel pump. The reviewer raised two questions for the authors: (1) Could they comment on how they plan to address the fuel lubricity issue related to propane-DME? (2) Will future work focus on any injector seat deterioration, which could lead to incomplete sealing of the injector tip after injection stops?

Reviewer 4:

The project team has simultaneously completed multiple workstreams, including fuel system modeling, fuel bench commissioning, fuel injector and fuel pump design and testing, spray testing, and vehicle drive cycle simulations to estimate CO_2 emissions. The reviewer commended the impressive progress made by the project team and expressed confidence that the project appears to be on track. The reviewer encouraged the project team to distinguish between the benefits derived from improved engine efficiency and fuel composition when presenting drive cycle fuel economy/GHG results. Additionally, the reviewer raised questions regarding the substantial (about 3%) brake thermal efficiency (BTE) benefit observed when using a DME and propane fuel mixture relative to diesel. The reviewer sought additional data to support these BTE improvement projections.

Reviewer 5:

The reviewer highlighted important observations made in the application challenges of lubricity agents and design requirements for the fuel injection system. The observation that relying on inlet metering can help with temperature control in liquefied gas fuel was considered an essential insight.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer noted that team member contributions are clearly explained and establish all the key disciplines.

Reviewer 2:

The reviewer said that the project team appears to be well-organized, with each member having a well-defined role. The team includes participants from a national laboratory, academia, and two industrial partners. However, the reviewer mentioned that the industrial partners do not include a large OEM capable of credibly commercializing this technology. Consequently, the commercialization path seems to involve developing and demonstrating the technology, with the intent to seek a commercialization partner in the future.

Reviewer 3:

The reviewer noted that the project, in collaboration with a university and a national laboratory, has demonstrated very effective collaborative research work. The resources from the various partners have been utilized successfully.

Reviewer 4:

The reviewer observed that the roles and deliverables of the multiple project partners (WM International, Argonne National Laboratory, Illinois Tech, Diversified CPC International, OEM) are clearly defined. The timely completion of all BP 1 tasks indicates very good collaboration across the project team.

Reviewer 5:

The reviewer highlighted that the partnership is broad and comprehensive, providing the necessary skills and connections to increase the likelihood of an overall successful outcome.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The project plan was acknowledged by the reviewer as covering the necessary steps to validate a method and hardware for a propane-DME compression ignition experimental engine.

Reviewer 2:

The proposed future work was described as well-organized and clear. The reviewer expressed interest in seeing the results of future engine tests.

Reviewer 3:

The reviewer expressed curiosity about the potential translation of the impressive injector spray work to in-cylinder combustion and suggested that engine test data from future work would be interesting to observe.

Reviewer 4:

The reviewer found that the next steps, particularly for the next year, are clearly defined. The tasks for BP 2 were considered well-defined and planned. Given that one of the project's deliverables is to improve emissions capability from ultra-low emissions vehicle (ULEV) 50 to ULEV 30, the reviewer encouraged the project team to clearly define the calibration and validation plan for emissions compliance.

Reviewer 5:

The reviewer concluded that the plans for BP 2 are appropriate and are expected to yield valuable outcomes. The plan was commended for its clear explanation and presentation.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer expressed the need for further explanation of the project's relevance to the VTO mainstream objectives, which include reducing CO_2 emissions and improving mobility. The reviewer suggested providing benchmarks against other fuels and inquired if the applicability to medium- and HD vehicles might be greater.

Reviewer 2:

The reviewer acknowledged that the project could be viewed as relevant but also considered an alternative viewpoint. The reviewer highlighted the relevance of developing new fuel system technologies for liquefied gaseous fuels while expressing reservations about the mixing of propane and DME and the lifecycle analysis portion of the work. The reviewer questioned the use of renewable fuels to offset CO_2 emissions, emphasizing that U.S. CO_2 emission targets are measured at the tailpipe. The reviewer suggested a more straightforward approach to evaluating tailpipe CO_2 emissions against targets.

Reviewer 3:

The reviewer found the project highly relevant to improving the state of the art in propane-fueled engines. The development of high-pressure direct fuel injection was seen as the next step to maximize the benefits of propane as an automotive fuel, particularly for certain applications.

Reviewer 4:

The reviewer stated that the project was viewed as aligned with DOE's goal of enhancing engine efficiency and utilizing alternative/low carbon fuels to improve vehicle efficiency and reduce GHG emissions.

Reviewer 5:

The reviewer noted that liquefied gaseous fuels have significant potential to provide low GHG emissions. The work was deemed valuable in advancing the field and the technologies available to consumers.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that the resources appear adequate for objectives. It is recommended to indicate which of team are receiving DOE funding.

Reviewer 2:

The reviewer noted that the project resources seem sufficient.

Reviewer 3:

The reviewer said the funding is sufficient for the proposed work.

Reviewer 4:

The reviewer stated that the resources are appropriate for a project with this technical scope.

Presentation Number: DORMA034
Presentation Title: Low-Mass and High-Efficiency Engine for Medium-Duty Truck Applications
Principal Investigator: Qigui Wang (General Motors)

Presenter

Qigui Wang, General Motors

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 25% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

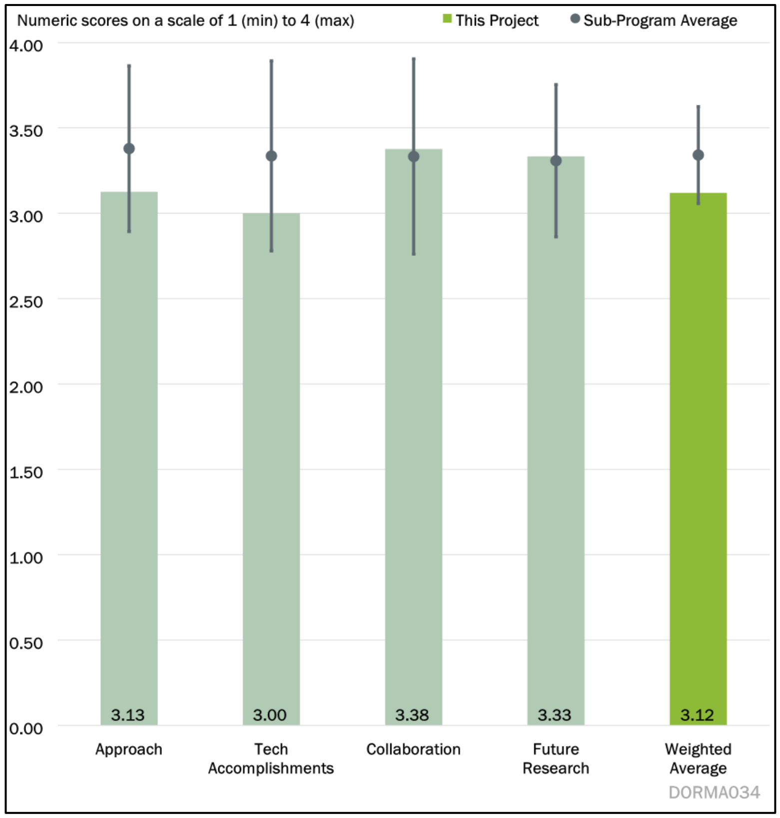

Figure 3-33 - Presentation Number: DORMA034 Presentation Title: Low-Mass and High-Efficiency Engine for Medium-Duty Truck Applications Principal Investigator: Qigui Wang (General Motors)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer remarked that upon reviewing the response to the reviewer comments from the previous year, it is evident that the comments made this year closely mirror those of the past. The actual fuel economy gains, as seen on Slide 8, are notably less than the originally predicted figures, and achieving successful project completion appears even more challenging at this stage.

Reviewer 2:

The reviewer expressed that the approach employed in the project is technically solid but leans towards the conservative side. The reviewer suggested that more attention could be directed towards exploring the air handling system with variable breathing in greater depth.

Reviewer 3:

The reviewer observed a logical and comprehensive approach presented in the project.

Reviewer 4:

The reviewer affirmed that, in their opinion, the overall approach is commendable. It commenced with simulations, progressed to engine development and testing, and is now entering the phase of fabrication and performance verification. However, the reviewer proposed that the project would benefit from concluding with vehicle testing.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer stated that given the state of project completeness, with an anticipated end date in March 2024 and approximately 9 months remaining, the accomplishments are considered fair. While some improvements have been achieved, the actual outcomes fall significantly short of the initial goals, and the principal investigators convey a sense of contentment with the current state.

Reviewer 2:

The reviewer observed that it is evident that a substantial gap still exists between the simulations and the testing results, as illustrated in Slide 8.

Reviewer 3:

The reviewer praised the technical accomplishments, highlighting that the only concern in the materials segment of the project, as indicated in the question and answer, is the variability in additive manufacturing.

Reviewer 4:

The reviewer commented that the project has incorporated various advanced combustion technologies, including higher compression ratios, increased EGR, and full CDA, among others. The project outlines a clear pathway toward achieving an overall engine mass reduction of more than 15%, with some of the reductions achieved through material changes such as transitioning from cast iron to aluminum. Notably, the inclusion of additively manufactured pistons is a valuable contribution. The reviewer affirmed that the quantification of actual fuel economy benefits and the comparison with simulations, which are not always provided, is appreciated. This comparison is deemed essential for identifying further opportunities for improvement, both on the hardware and simulation fronts.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer affirmed the presence of clearly defined roles for all collaborators.

Reviewer 2:

The reviewer remarked that it appears that all partners are actively engaged and fulfill their designated roles in the project.

Reviewer 3:

The reviewer commented that while the roles of the collaborators were well described on Slide 16, it would be beneficial if individual contributions were prominently highlighted on the technical accomplishment slides as well. The reviewer noted that the proposed future work effectively outlines this aspect.

Reviewer 4:

The reviewer observed that collaboration across partners seems to be functioning effectively, although assessing the exact level of contributions from other partners proves challenging.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer expressed that, at this point, the project has all but ended. There were no plans presented to get this project back on track to deliver at the promised levels of light-weighting and efficiency.

Reviewer 2:

The reviewer noted that the future research includes detailed steps to achieve the project goals.

Reviewer 3:

The reviewer articulated that the layout is nicely done and provides good detail about the contributors involved.

Reviewer 4:

The reviewer suggested that, apart from completing the fuel economy assessment, it would be beneficial to quantify the emissions from the engine. Additionally, it might be useful to revisit and investigate the discrepancy between simulations and measured fuel economy improvements. Regarding CDA, the reviewer proposed that it would be valuable to showcase the improvements at various operating conditions, such as higher improvements at low loads.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer affirmed that the goal of the project is relevant to VTO goals.

Reviewer 2:

The reviewer observed that reducing both fuel consumption and weight would unquestionably support the overarching VTO program objectives.

Reviewer 3:

The reviewer commented that the project's objectives of reducing energy usage, CO_2 emissions, and increasing energy security align well with the program's overarching objectives.

Reviewer 4:

The reviewer emphasized that the project's aim to reduce fuel consumption is a pivotal focus of the contemporary transport industry.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer expressed that the amount of money spent on this project is substantial, given the relatively modest results achieved. This project unfavorably compares to the Ford project with similar objectives.

Reviewer 2:

The reviewer remarked that it appears the project is adequately funded to achieve its stated goals.

Reviewer 3:

The reviewer commented that, as one of the larger projects, the level of funding allocated seems appropriate, considering the project's expansive scope and ambitious goals.

Reviewer 4:

The reviewer observed that the project is progressing on track for completion with its existing resources, indicating that the resources are sufficient.

Presentation Number: DORMA035
Presentation Title: Next-Generation, High-Efficiency Boosted Engine Development
Principal Investigator: Michael Shelby (Ford)

Presenter

Michael Shelby, Ford

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

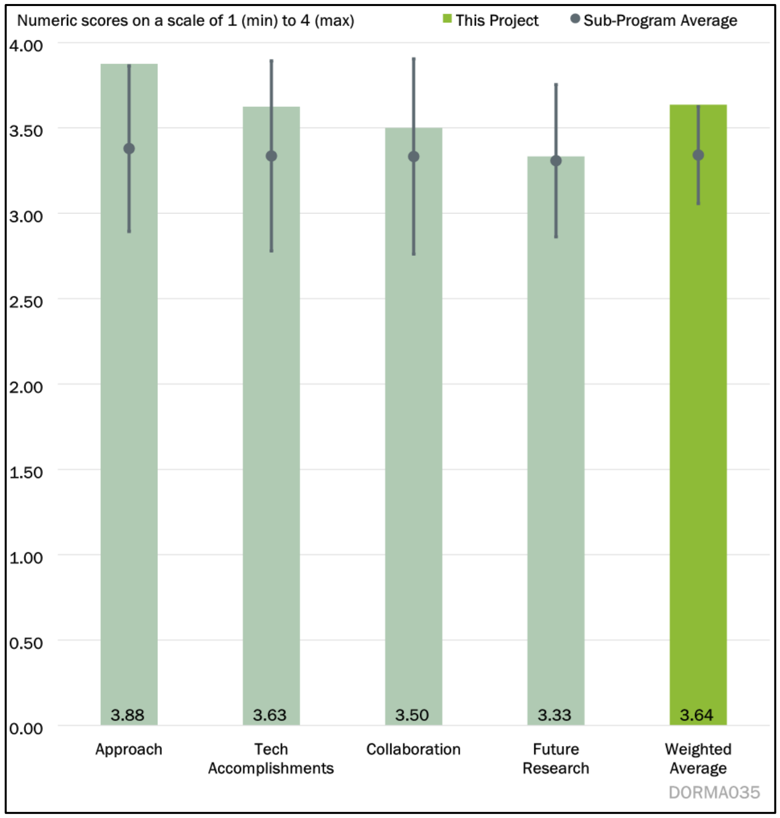

Figure 3-34 - Presentation Number: DORMA035 Presentation Title: Next-Generation, High-Efficiency Boosted Engine Development Principal Investigator: Michael Shelby (Ford)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer praised the project for its intelligent and well-integrated approach, utilizing advanced analytical tools and conducting dynamometer testing on both single-cylinder and multi-cylinder engines and models. This approach aims to design and construct a lightweight engine with improved fuel economy to reduce the CO_2 emissions of the largest volume engine in the Ford fleet.

Reviewer 2:

The reviewer commented that the approach taken is comprehensive, which should significantly contribute to the project’s ability to achieve its goals.

Reviewer 3:

The reviewer affirmed that this project is thoughtfully designed and explores a broad spectrum of reasonably known technologies available for enhancing efficiency and reducing weight.

Reviewer 4:

The reviewer observed that the project is nearing completion and has been executed effectively. All barriers were identified, and work was carried out at various levels, encompassing modeling, single-cylinder and multi-cylinder engine testing, and dynamometer studies.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer noted that technical accomplishments to date are substantial. Single-cylinder and multi-cylinder engines, along with their support systems, have been successfully designed and tested. Moreover, the majority of final vehicle testing has been completed.

Reviewer 2:

The reviewer acknowledged that the project has made remarkable progress in both fuel consumption and weight reduction. Nevertheless, the delay in the final engine delivery is concerning in terms of the overall project timeline.

Reviewer 3:

The reviewer emphasized that the project has effectively met or exceeded all of its goals, with only minor tradeoffs.

Reviewer 4:

The reviewer stated that the two multi-cylinder engines have been constructed, implementing a range of engine enhancements, such as increased compression ratio, pre-chamber ignition, higher EGR, and continuously variable valve timing, among others. Substantial weight reduction efforts have been undertaken for various engine components. The project has outlined a feasible pathway to achieving a 15% reduction in engine weight. Although the improvements in fuel economy have been targeted, they are yet to be quantified in the final demonstration. The reviewer commended the inclusion of criteria pollutant emissions reduction and the expectation of early three-way catalyst light-off.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer articulated that the response to previous review comments effectively clarified participant roles and collaborative efforts.

Reviewer 2:

The reviewer observed that it appears that all partners actively fulfill their designated roles in supporting the project.

Reviewer 3:

The reviewer noted that while there are not many partners, notably, this team lacks a university partner.

Reviewer 4:

The reviewer praised the effective collaboration with various project partners in ensuring that the project proceeded mostly on time, albeit with some delays. The principal investigator made a comment that underscored the substantial contributions of all partners leveraging their respective strengths.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer stated that the project is scheduled to conclude in the third quarter of this year, with only the end-of-project work remaining.

Reviewer 2:

The reviewer commented that the future research plans encompass all the essential steps required to attain the final project goals.

Reviewer 3:

The reviewer noted that future work has been identified to progress towards the project's conclusion later this year.

Reviewer 4:

The reviewer mentioned that as the project is nearing completion, there is not much left to address in terms of future work. However, it could have been advantageous to consider hybridization as part of the project's scope.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer expressed that the project clearly supports the development of energy-efficient mobility systems.

Reviewer 2:

The reviewer remarked that reducing both fuel consumption and weight would undeniably contribute to the overarching goals of the VTO program.

Reviewer 3:

The reviewer commented that the efforts to improve efficiency and reduce vehicle weight align well with the objectives of DOE VTO.

Reviewer 4:

The reviewer emphasized that reducing fuel consumption is a pivotal requirement for addressing transportation costs and reducing GHG emissions.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that the project is nearly complete and has remained on budget.

Reviewer 2:

The reviewer expressed confidence that the project should possess adequate funding to achieve its project goals, particularly with the additional 9-month extension.

Reviewer 3:

The reviewer affirmed that the significant DOE funding and the scale of the project are justified by the challenging and ambitious objectives set. The funding level is regarded as appropriate given the complexity of the project.

Reviewer 4:

The reviewer observed that it appears the resources allocated to the project have been sufficient, allowing the work to progress nearly on schedule.

Presentation Number: DORMA036
Presentation Title: SuperTruck 2 – PACCAR
Principal Investigator: Maarten Meijer (PACCAR)

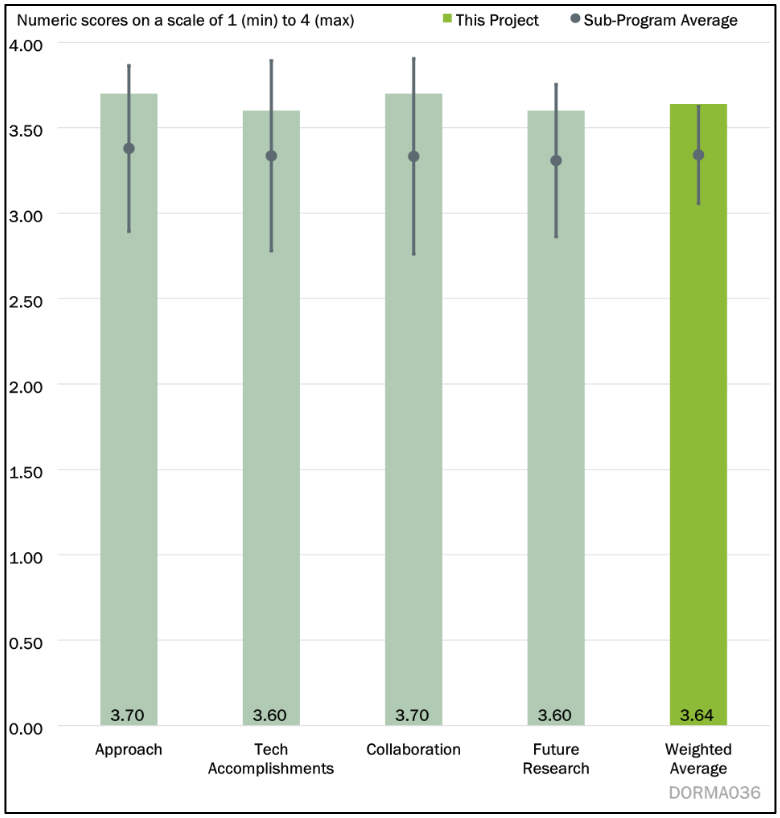

Figure 3-35 - Presentation Number: DORMA036 Presentation Title: SuperTruck 2 – PACCAR Principal Investigator: Maarten Meijer (PACCAR)

Presenter

Maarten Meijer, PACCAR

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer stated that the project is nearly complete and has successfully achieved the expected targets, resulting in substantial learning and knowledge that will benefit freight efficiency. For future endeavors with similar objectives, it is recommended that low-carbon fuels be considered as part of the solution for freight CO_2 reduction targets.

Reviewer 2:

The reviewer pointed out that the goals of this project are highly ambitious, with a target of achieving a 120% improvement in efficiency compared to a 2009 baseline. This improvement is to be achieved while maintaining a BTE of better than 55% and using technology with a 3-year payback period. The approach to achieve these objectives encompasses a blend of engine, hybrid, lightweighting, and aerodynamic technologies, leaving no stone unturned in the quest to reach this goal.

Reviewer 3:

The reviewer commended the comprehensive approach taken, which represents the state of the art in all advanced technology domains. However, the reviewer noted a drawback related to the use of Cummins’ waste heat recovery (WHR) technology, which could potentially create conflicts of interest and be considered unfair to its competitors.

Reviewer 4:

The reviewer highlighted that the project has successfully addressed barriers in order to meet its objectives, demonstrating a successful approach.

Reviewer 5:

The reviewer noted that the project team has systematically and holistically explored numerous avenues for improving engine and vehicle-level efficiencies. This exploration included testing several new or advanced components related to engine and powertrain, weight reduction, drag reduction, trailer architecture, aerodynamics, and more.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer noted that the WHR technology used in the project was somewhat borrowed from Cummins. However, it was constructive to conclude that this specific form of WHR is not cost/weight competitive for the efficiency benefits it offers.

Reviewer 2:

The reviewer observed that the major tasks of completing the truck build and executing the demonstration are yet to be completed.

Reviewer 3:

The reviewer suggested that the project's accomplishments could have been outstanding if it had not used a competitor's WHR technology, as this could create an unfair playing field in the market. Many of PACCAR's competitors have invested significant resources in developing their own WHR systems, making it essential to uphold fairness and competitiveness.

Reviewer 4:

The reviewer highlighted that the final truck build and the payback demonstration are the only remaining tasks, describing the project as great.

Reviewer 5:

The reviewer detailed the project's investigation of various key aspects of engine and vehicle technologies to achieve BTE and freight efficiency goals. These aspects included engine efficiency improvements to meet the project target, the development and implementation of new technologies like long stroke engines, two-stage charging, and a 48V EGR pump. The project also involved testing a WHR system, 48V hybridization, achieving ultra-low NO_x compliance with close-coupled SCR, a gasoline compression ignition engine, weight reduction by 30% in chassis and suspension, and the use of low rolling resistance tires, among other measures. The overall improvements in powertrain efficiency, weight reduction, and aerodynamic drag reduction were deemed very impressive, with an overall freight efficiency improvement of approximately 150%.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer commended the team for its excellent performance and collaboration.

Reviewer 2:

The reviewer acknowledged the strength of the team but noted that partner roles are not obvious or clearly defined.

Reviewer 3:

The reviewer observed that the team fully utilizes the strengths of all partners.

Reviewer 4:

The reviewer pointed out that Slide 20 provides a clear and helpful summary of the partners and their roles. In future projects, it would be beneficial to identify the collaborators' contributions on the technical accomplishment slides as well.

Reviewer 5:

The reviewer concluded that the overall collaboration is excellent, with advanced components provided by partners on the team.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer mentioned that the project is nearly finished, with clear plans for on-road vehicle studies.

Reviewer 2:

The reviewer noted that there is a clear pathway to successfully complete the project ahead.

Reviewer 3:

The reviewer expressed that the future work is well-defined and aligns with the direction needed to achieve all the project goals.

Reviewer 4:

The reviewer emphasized that the project is in the final stages of completion at the end of the calendar year, and the proposed future work is instrumental in helping the team cross the finish line.

Reviewer 5:

The reviewer pointed out that a few remaining tasks have been identified, which are in line with what is typically expected in the final months of the project. These tasks include completing the vehicle build and demonstrating its performance on the road. Additionally, it is important to present the payback period calculations.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer noted that many findings and developments from the project are expected to have a significant impact on improving freight movement.

Reviewer 2:

The reviewer affirmed that the SuperTruck projects are directly relevant to the objectives of the VTO.

Reviewer 3:

The reviewer stated that the achievement of the engine and vehicle performance goals effectively supports the overall objectives of the DOE program.

Reviewer 4:

The reviewer emphasized that the project's major objectives are well-aligned with the DOE VTO objectives. These objectives include a 120% improvement in freight efficiency relative to a 2009 baseline, achieving a BTE of at least 55%, and ensuring a 3-year payback period on developed technologies.

Reviewer 5:

The reviewer highlighted that reducing fuel consumption is a critical need in the transportation sector, and this project effectively addresses that need.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer observed that the project appears capable of reaching completion within the planned budget.

Reviewer 2:

The reviewer noted that the resources appear to be sufficient for the project's needs.

Reviewer 3:

The reviewer expressed confidence that the remaining funding should be adequate to successfully complete the project.

Reviewer 4:

The reviewer commented that the funding levels for the SuperTruck project are notably high, but the extensive work required for technology integration and building demonstrator trucks justifies the higher costs.

Reviewer 5:

The reviewer concluded that the project is nearing successful completion, indicating that the resources allocated were indeed sufficient.

Presentation Number: DORMA037
Presentation Title: SAF Specifications and Testing Protocols
Principal Investigator: Gina Fioroni (National Renewable Energy Laboratory)

Presenter

Gina Fioroni, National Renewable Energy Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 80% of reviewers felt that the resources were sufficient, 20% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

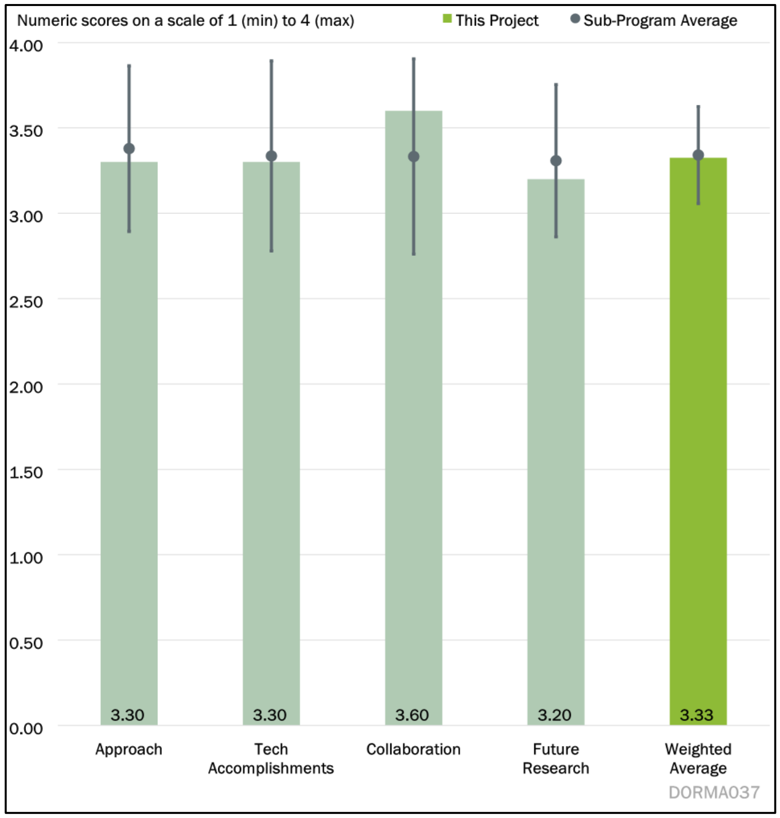

Figure 3-36 - Presentation Number: DORMA037 Presentation Title: SAF Specifications and Testing Protocols Principal Investigator: Gina Fioroni (National Renewable Energy Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer suggested that as the team makes progress in their NASA and OEM geometry validations, they should work closely with the industry to refine industry-scale codes and design tools, allowing for further model improvements and optimization.

Reviewer 2:

The reviewer recommended that the project, while studying the properties of liquid fuels over a wide range of temperature and pressure conditions, should focus on specific properties and/or conditions that have a significant impact on combustor operability or emissions.

Reviewer 3:

The reviewer acknowledged that the project had many aspects, leading to the identification of numerous barriers that will evolve as the work progresses. Despite this complexity, the reviewer recognized the team’s excellent work in resolving expected barriers. They noted the project’s emphasis on improved test methods for measuring fuel properties, pathways for utilizing 100% SAF in aircraft, examination of new fuels and components, and new fuel property measurements at extreme conditions. The reviewer also indicated that the future work section should provide additional insights into how identified barriers may be refined and focused.

Reviewer 4:

The reviewer described the focus of efforts in the NREL program, emphasizing measurements of SAF properties and exascale calculations of SAF sprays and combustion processes at relevant conditions.

Reviewer 5:

The reviewer provided an overview of the project's goals, which involve developing a SAF with the aim of achieving a 100% substitution for Jet A. They mentioned the focus on building a database of properties for Jet A and "emerging" SAFs, as well as experiments on combustors with varying complexities for comparison. The reviewer noted the challenge in connecting the results from basic burners to turbine performance metrics and recommended clarification in this regard. Additional comments included the importance of sharing results with the ASTM Committee D02, Subcommittee D02.J0.06 on Synthetic Aviation Turbine Fuels (SATF). The reviewer expressed some confusion about which SAF is being considered as a 100% replacement for Jet A and requested clarification on SAF types mentioned. The reviewer also suggested discussing the expectations of SAF costs, as high costs could impact airline ticket prices and the global economy.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer noted that the team has established good fuel characterization capabilities and identified reference validation cases of technical relevance.

Reviewer 2:

The reviewer pointed out that while properties beyond viscosity may have been measured over a wide range of temperatures, the project is purchasing new equipment for large temperature-pressure ranges for density, viscosity, and surface tension, as well as a thermal stability rig. The reviewer recommended checking for similar or complementary thermal stability measurements at Air Force Research Laboratory or University of Dayton Research Institute.

Reviewer 3:

The reviewer acknowledged that the project team has identified new experimental facilities that can expand the range of known property data for fuels. This expansion was illustrated through viscosity data, while new datasets for density and surface tension were mentioned. The reviewer suggested that in future works, uncertainties in the new datasets should be included or referenced. The project also examined new fuel components, such as dimethyl-cyclooctane, and produced new property data that showcased positive attributes compared to conventional jet fuel. The project engaged in new simulations using PeleLM, enabled by exascale computing, on a lean direct injector (LDI) design combustor, which was not considered under the National Jet Fuel Combustion Program. The reviewer recognized the importance of addressing different combustor designs and operating conditions, considering that different engine configurations and conditions may exhibit varying sensitivities to fuel properties. The reviewer concluded that, based on the progress to date, it is reasonable to expect the completion of the FY 2023 Q4 milestones as stated in the presentation.

Reviewer 4:

The reviewer acknowledged the good progress made by the National Renewable Energy Laboratory team in both measuring SAF properties and advancing exascale simulation efforts. The reviewer emphasized the importance of measurements on SAF properties, particularly for low-temperature surface tension and density data and viscosity data for SAF/conventional fuel blends. The reviewer also raised questions about the volume and yield of synthesized SAFs, cost estimates, and purity levels. Additionally, the reviewer inquired about the focus of spray studies and the differences from ground transportation systems.

Reviewer 5:

The reviewer noted some uncertainties and aspects requiring clarification, such as the specific SAF or SAF blend being simulated in temperature-pressure variations, the quantitative connection between surface tension and engine efficiency, the accuracy of surface tension measurements at elevated temperatures, the use of surrogates for SAFs, the lack of effort in determining gas phase property data, and the need for developing new data at extreme conditions for accurate simulations. The reviewer highlighted that the work plan should address these considerations more explicitly.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer commended the team for being well-coordinated and establishing excellent collaboration across multiple research entities.

Reviewer 2:

The reviewer noted that the collaboration efforts are directly contributing to the project's goals. Collaborations include testing of combustors with various fuels at GE or Georgia Tech (under Federal Aviation Administration (FAA) Aviation Sustainability Center and NASA University Leadership Initiative, utilization of existing data from NASA Glenn, provision of kinetics and property routines for high-fidelity simulations by Lawrence Livermore National Laboratory and Argonne National Laboratory, and property measurements collaboration with the Bioenergy Technologies Office. New fuels are provided by the Navy, and there is a collaboration with Washington State University for ignition delay, though the exact nature of that collaboration was not entirely clear.

Reviewer 3:

The reviewer acknowledged the superb composition of the broader team, which covers a wide range of expertise and talent needed to address the project's requirements. Collaboration was highlighted as key to the project's success, given the diverse sources of funding from the FAA, NASA, Navy, and various DOE laboratories, involving government entities, universities, and an engine OEM. The coordination and interaction between Georgia Tech/GE and DOE were identified as critical for the project, as modelers require precise hardware and operational details, test methods, diagnostic sensitivity, and data interpretation. The reviewer pointed out that while experimental work was not yet complete, modeling results had already been generated, providing pre-test predictions in advance of the experiments. The reviewer expected that very useful data would be obtained to validate the computational model.

Reviewer 4:

The reviewer commended the team for its excellent efforts in establishing relevant external collaborations.

Reviewer 5:

The reviewer assessed the project team as excellent, encompassing groups with expertise in various elements, including single burning studies, kinetic modeling, SAF property determination, ignition delay studies, and fuel properties. However, there were concerns about how these components were coordinated within the project.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer raised questions and provided recommendations regarding the project's vision for validating the chosen geometries, particularly regarding the challenge of ensuring that the modeling effort remains agnostic to any specific OEM geometry. The reviewer emphasized the importance of developing models and data that are broadly applicable and valuable for the community at large.

Reviewer 2:

The reviewer noted that the work started in FY 2022, and the presentation only covered future work up to FY 2024 without a detailed timeline. The reviewer acknowledged that the proposed FY 2024 work directly addresses the barriers identified.

Reviewer 3:

The reviewer highlighted the need for close coordination and discussions with key groups, including ASTM committees, FAA, Commercial Aviation Alternative Fuels Initiative, European Union partners, and other entities with similar objectives. This collaboration was seen as critical for maximizing the impact of DOE's efforts. The reviewer recommended developing a deep understanding of the accuracies and uncertainties required for different properties as a function of temperature. This understanding should take into account both the sensitivity of combustor parameters to fuel properties and the sensitivity of numerical predictions to combustor performance. The reviewer suggested assessing existing accuracies and uncertainties in existing measurements to compare with what is possible and what is needed. The reviewer also recommended using reaction-observation models for early sensitivity analyses, discussing with OEMs to collect critical information, and identifying additional barriers and research priorities through discussions with OEMs and ASTM members. The reviewer recommended that future work include modeling and testing of alternative combustor configurations and different operating conditions, as sensitivities to fuel properties may vary. The work on a specific operating condition for the LDI burner should be viewed as a starting point. The reviewer also urged the team to consider the interdependence of fuel properties in subsequent studies and work on refining theory/models for predicting the properties of fuel blends, particularly for large molecule hydrocarbon components. The reviewer raised a minor issue regarding the relative benefits of the new ignition testing device and its accuracy in determining cetane number and/or derived cetane number. The reviewer suggested increased coordination and collaboration with the 038 project team, led by Dasgupta, especially in the modeling area.

Reviewer 4:

The reviewer noted that the proposed future work was well thought out in terms of SAF property measurements but lacked details regarding exascale simulations.

Reviewer 5:

The reviewer found the plan to develop new equipment and expand the range of property data to be obtained suitable. However, the plan to "probe kinetics" was unclear, and the presentation lacked specificity regarding the structure/property relations and validation. The reviewer emphasized the importance of addressing the development of surrogates for validation purposes.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer noted that the project has the potential to serve as a blueprint for best practices in coordinating industry and federal laboratory efforts to address SAF challenges in the aviation sector.

Reviewer 2:

The reviewer emphasized the importance of the project in enhancing the understanding of the impacts of using SAFs in aircraft engines. It was noted that while a substantial amount of experimental data on synthetic hydrocarbon fuels has been collected over the past two decades, there is still a need for a comprehensive understanding of SAF behavior across the entire range of operating conditions, especially for current and next-generation gas turbine engines.

Reviewer 3:

The reviewer raised concerns about the outdated link in question 9, which did not include updated objectives of the VTO. However, based on separate sources, the main VTO objective deduced was to "Enable the use of drop-in unblended SAF and SAF blends up to 100%." The reviewer affirmed that the project's work aligns with and supports this objective. The project addresses various aspects, including accurate property measurements, the development of new simulation tools, the synthesis and assessment of new fuel components, and coordination with other groups and teams both within and outside DOE who share common goals.

Reviewer 4:

The reviewer acknowledged the project's relevance to the DORMA subprogram.

Reviewer 5:

The reviewer approved of the project's broader relevance in the context of combustion technologies using SAFs.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer found that computational resources appear to be adequate and readily available. Experimental capabilities and fuel availability also appear to be adequate.

Reviewer 2:

The reviewer stated that budgets for FY 2021 and FY 2022 look appropriate for the scope of work. The reviewer noted that no details are provided on the split between people and procurements, so it is difficult to make a detailed assessment.

Reviewer 3:

The reviewer scored the funding as insufficient, noting that in reality, there are a great number of additional efforts that could be pursued. Many of these are highlighted in the future work section. Of course, this is a management decision, balancing many conflicting priorities. While there are several other organizations that might be contributing to the key goals of this effort, the reviewer suspected many will be taking engineering solutions as opposed to enhancing the science base for making decisions. The latter is generally more of DOE focus and ownership of capability; hence the reviewer attributed more responsibility to the DOE budget to enhance such capabilities.

Reviewer 4:

The reviewer commented the resources appear to be sufficient.

Reviewer 5:

While resources were generally considered adequate, the reviewer emphasized that without detailed information, it would be challenging to make a comprehensive judgment. A more thorough assessment would require a cost/benefit analysis based on DOE's investment relative to the potential commercialization of the SAFs or synthetic aviation turbine fuels being studied.

Presentation Number: DORMA038
Presentation Title: Towards accurate reacting flow simulations of SAFs
Principal Investigator: Debolina Dasgupta (Argonne National Laboratory)

Presenter

Debolina Dasgupta, Argonne National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 40% of reviewers felt that the resources were sufficient, 60% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

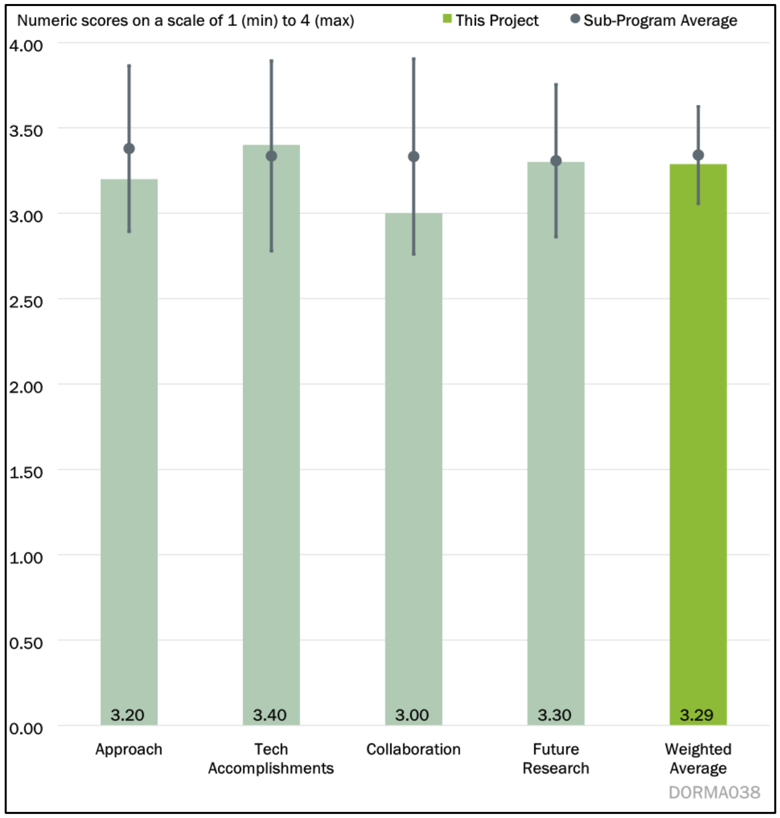

Figure 3-37 - Presentation Number: DORMA038 Presentation Title: Towards accurate reacting flow simulations of SAFs Principal Investigator: Debolina Dasgupta (Argonne National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The approach to the work plan was commended as solid, particularly the utilization of the CFD development rooted in a previous project, the National Jet Fuel Combustion Program (NJFCP). The reviewer appreciated the small “deltas” to fuel properties leveraged from existing work. However, a caution was raised regarding the importance and challenges of spray modeling, given its sensitivity to various fuel properties.

Reviewer 2:

The reviewer expressed the need for the team to identify and develop models that are agnostic to geometry, covering various combustion scenarios from rich burn to lean or lean premixed and prevaporized combustion. The reviewer emphasized the importance of considering commonalities with the aero-engine sector and prioritizing computational simulation activities.

Reviewer 3:

The exploration of fuel property impacts within the limits of ASTM specifications using high and medium fidelity simulations was seen as beneficial. The reviewer highlighted the use of two codes, Nek5000 and CONVERGE, and two experiments, Army Research Combustor-Midsize (ARC-M1) and NJFCP Referee Rig, focusing on single-cup rich-burn combustor designs. The project’s goals to assess fuel property impacts on lean blowout, cold start, and high-altitude relight were noted as directly addressing technical barriers.

Reviewer 4:

The reviewer identified the three main barriers identified by the project team: assessment of fuels, heat transfer for durability examination, and tools for predicting combustor instability and ground-level noise. The reviewer acknowledged the significance of addressing these barriers but stressed the need for further work on demonstrating and validating the simulation tools, especially concerning combustor instability and noise prediction.

Reviewer 5:

According to the reviewer, the research team's use of state-of-the-art computational tools for modeling the ARC-M1 and the NJFCP Referee Rig was noted in the feedback.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer found this area to receive the highest mark and was most impressed with how the completed work had progressed and approached technical barriers. It was clear that the simulation framework had been established, and an approach for the "deltas" to the fuel properties had been set up. In the reviewer's opinion, many of the technical challenges had been completed, and it was now just a matter of working through the simulations test plan.

Reviewer 2:

The reviewer encouraged the team to identify current modeling gaps in the OEM community so that their efforts aligned with industry needs. Moreover, the reviewer requested that the team closely work with industry and federal laboratory experts in this area for results interpretation. Validation of the simulations needed to be performed to assess model accuracy. The reviewer also noted the importance of identifying metrics for quantitative comparisons.

Reviewer 3:

Non-reacting simulations with Nek5000 were completed for ARC-M1, which was considered a formidable undertaking by the reviewer. Reacting simulations at stable flame conditions were completed with CONVERGE for the Referee Rig, examining variations in Jet A density, viscosity, and heat of combustion. The reviewer acknowledged that a large amount of effort would likely be required to achieve reacting spray simulations of ARC-M1 with Nek5000 and simulations of ignition (cold start and high-altitude relight) with CONVERGE for the Referee Rig.

Reviewer 4:

The reviewer recognized this as a relatively new project with limited resources, and thus, accomplishments were expected to be limited. The relatively high score, according to the reviewer, took this limitation into account. The project team, in the reviewer's assessment, successfully demonstrated simulations of the (non-reacting) flow field in the ARC-M1 combustor, using Nek5000 and applying high-fidelity wall-resolved modeling. This was seen as the first such simulation the reviewer had encountered (of this burner), although they acknowledged the possibility of other similar simulations. The reviewer considered this a significant step toward reacting flow simulations with vaporizing sprays. Of particular interest to the reviewer was the team's performance of reacting flow simulations of the NJFCP Referee rig with A-2 fuel, wherein they varied independently, and jointly, three fuel properties (viscosity, density, and heat of combustion) to observe the impact on the flame structure. The reviewer found these results very interesting and noted that if they could be validated, this capability could be highly useful in subsequent assessments of SAF being examined for 100% utilization. While not critical to the main message of the slides, the reviewer suggested it would be useful to include the specific conditions under which the simulations were performed, and perhaps useful to provide comparisons to simulations using CONVERGE or other CFD modeling tools, so that potential benefits of the Nek5000 work could be assessed readily. The reviewer acknowledged that the latter might increase project costs.

Reviewer 5:

The reviewer emphasized that simulation of these reacting flows with sprays was very challenging, and the simulation results did provide valuable insight into the flame structure in these experiments.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer remarked that the presentation identified several collaborators, primarily working in conjunction with the NJFCP. The reviewer believed that the identified partners are appropriate and will help establish a strong team. However, the reviewer recommended considering a partner who can contribute to spray modeling and provide insights from their involvement with the NJFCP.

Reviewer 2:

The reviewer stated that the team is requested to closely collaborate with industry and federal laboratory experts in this area for results interpretation, identification of modeling gaps, and validation needs.

Reviewer 3:

The reviewer commented that this work makes good use of existing experiments, such as the ARC-M1 and NJFCP Referee Rig, as a platform for code validation and exploring the impacts of fuel property variations. The reviewer suggested exploring potential collaboration with DORMA037, which also involves simulations with fuel property variations using different codes and different experiments.

Reviewer 4:

The reviewer affirmed that coordination with the team is very effective. In particular, the sharing of information on priorities from the NJFCP industry partners is clear. Furthermore, the University of Illinois Urbana-Champaign (UIUC) is providing detailed information on their burner, and the U.S. Army Research Laboratory is granting approval for sharing such information. The reviewer expected substantial sharing of experimental results and observations of fuel-property effects during interactions in the coming year. The reviewer also anticipated results from Convergence Science or their software during the coming year. Such coordination efforts may need to be expanded. The team will require validation datasets, and the old NJFCP datasets and new UIUC data could be useful. Additionally, there is new data developing from the collaboration between the Georgia Institute of Technology, the Federal Aviation Administration, and General Electric interactions. The reviewer also encouraged coordination with the DOE team in Colorado, who share similar interests, even though that might already be occurring but is not cited. Coordination with other strong CFD groups, such as Stanford, Princeton, and commercial groups like Fluent/Ansys, could be fruitful and help demonstrate the advantages of DOE simulation capabilities.

Reviewer 5:

The reviewer verified that the principal investigator has successfully established the necessary collaborations to obtain the required boundary conditions for the simulations and the data needed for comparison with the calculated results.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer expressed their opinion that the proposed future work aligns with the right path, and they are pleased to see it presented in the review. They noted that the small “deltas” to the fuel properties will provide valuable insight and intuition, directly impacting accelerated fuels certification/acceptance. However, the reviewer raised concerns about the readiness of solid mechanisms and spray models to translate these deltas into simulations.

Reviewer 2:

The reviewer inquired about the team’s approach to validation needs for various combustion regime operations encountered in a realistic engine. Furthermore, they sought information on how the models would be assessed and validated for changing combustion modes.

Reviewer 3:

The reviewer praised the goals of the future research as excellent but expressed concerns regarding the availability of resources to achieve the ambitious goals, especially in simulating ignition events (cold start and high-altitude relight) and capturing fuel property impacts.

Reviewer 4:

The reviewer discussed the future plans, which include examination and interpretation of data sets from the Referee Rig (NJFCP), the ARC-M1 rig, and an unspecified swirl-stabilized flame. They highlighted the challenge of using these data sets for the validation of CFD codes and suggested encouraging those collecting experimental data to test fuels and conditions beyond their current scope. The reviewer also suggested engaging Stanford and/or NASA to develop experimental data sets and model development for chemical kinetic models suitable for new fuels. Additionally, they recommended comparisons to simulations using codes from other CFD groups for confirmation of capability. The reviewer noted that while there is likely coordination with the 037 project team (Fioroni), it was not explicitly mentioned, and they suggested increased coordination and collaboration between the teams.

Reviewer 5:

The reviewer considered the proposed future research efforts to be good and logical, particularly the extension of the current nonreacting flow modeling of the ARC-M1 to modeling of reacting flow. However, they expressed uncertainty about the feasibility of the proposed DNS of swirl-stabilized flame and inquired about the specifics of DNS of the spray.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer emphasized the high relevance of this work, highlighting its critical role in fast-tracking fuels certification/acceptance. They noted that understanding the effects of different fuel properties on performance metrics is essential, and this work directly addresses that need.

Reviewer 2:

The reviewer underlined the necessity of this project in overcoming current modeling gaps within the OEM community.

Reviewer 3:

The reviewer pointed out that this work significantly advances the understanding of fuel’s impact on combustor operability. They emphasized that this advancement is essential for the development and utilization of sustainable aviation fuels, which is a key approach for the aviation industry to achieve its net-zero carbon emissions goals by 2050.

Reviewer 4:

The reviewer expressed concerns about the outdated link provided in question 9 and suggested that they had deduced the main objective pertinent to the project through separate sources. They clarified that the main relevant objective from the VTO is to "Enable the use of drop-in unblended SAF and SAF blends up to 100%" and they affirmed that the project work aligns well with this objective. They further elaborated on the aspects covered by the project team, such as assessing fuel performance, modeling heat transfer for predicting its impact on engine component durability, and developing tools for predicting combustion instability and ground noise. The reviewer emphasized that these efforts, primarily through advancements in CFD simulation capabilities, are expected to confirm that minimal or no changes are anticipated in key operational metrics due to fuel property variations, as sought by the OEMs.

Reviewer 5:

The reviewer also pointed out the relevance of the research to the DORMA subprogram.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer raised concerns about the budget presented in the presentation, which indicates a budget of $200,000 for a 4-year project. They mentioned that, in their opinion, this budget appears to be extremely thin, unless it was intended as a yearly budget. The reviewer suggested that if significant funding is going out to collaborators, such as for kinetics, spray models, and the Air Force Research Laboratory, then the budget may be inadequate.

Reviewer 2:

The reviewer noted that the project seems to have adequate computational resources.

Reviewer 3:

The reviewer expressed uncertainty about whether the $200,000 listed in the presentation was an annual budget or the total budget for FY 2022–2023, starting in Q2 of FY 2022. They assumed there was no cost for using the CFD codes or performing simulations on DOE computing clusters. The reviewer pointed out that a budget of $100,000 or $200,000 per year for the goals outlined for FY 2024 appears insufficient, given the challenges of performing ignition simulations (cold start and high-altitude relight), capturing fuel property impacts, conducting lean blowout simulations, reacting spray simulations for ARC-M1, and performing DNS of a swirl-stabilized flame.

Reviewer 4:

The reviewer expressed the opinion that it seems the project team is operating with limited resources and may require additional funding. They acknowledged the project's powerful objectives, potential scientific contributions, and significant impact as reasons for the need for additional resources.

Reviewer 5:

The reviewer deemed the resources for the project to be sufficient.

Acronyms and Abbreviations – DORMA

Abbreviation	Definition
0D	Zero-dimensional
1D	One-dimensional
2-EHN	2-ethylhexyl nitrate
3D	Three-dimensional
ADT	Articulated dump truck
AEC	Advanced Engine Combustion
ANL	Argonne National Laboratory
APS	Advanced Photon Source
APU	Auxiliary power unit
ARC-M1	Army Research Combustor Midsize (ARC-M1)
ASTM	ASTM International, formerly known as American Society for Testing and Materials
BAs	Boron arsenide
BASF	BASF Corporation
BES	Basic Energy Sciences
BP	Budget period
BTE	Brake thermal efficiency
CDA	Cylinder deactivation
CFD	Computational fluid dynamics
CGM	Carbon-growth-on-metal
CI	Compression-ignition
CO	Carbon monoxide
CO_2	Carbon dioxide
COVID	Coronavirus disease (COVID-19), infectious disease caused by the SARS-CoV-2 virus
CRADA	Cooperative research and development agreement
CRC	Coordinating Research Council
CTL	Compact track loader
Cu	Copper
DC	Direct current
DEI	Diversity, Equity, and Inclusion

Abbreviation	Definition
DFI	Ducted fuel injection
DFT	Density functional theory
DI	Direct injection
DME	Dimethyl ether
DNS	Direct numerical simulation
DOC	Diesel oxidation catalyst
DOCF	Diesel oxidation catalyzed filter
DOE	U.S. Department of Energy
DORMA	VTO Decarbonization of Off-Road, Rail, Marine, and Aviation subprogram
DPF	Diesel particulate filter
DSF	Dynamic skip fire
ECN	Engine Combustion Network
EERE	Office of Energy Efficiency and Renewable Energy
EGR	Exhaust gas recirculation
EV	Electric vehicle
FAA	Federal Aviation Administration
Fe-zeolite	Iron zeolite
FN	Foreign national
FTP	Federal Test Procedure
FY	Fiscal Year
GE	General Electric, Inc.
GHG	Greenhouse gas
GM	General Motors
H_2	Hydrogen
H_2O	Water
HD	Heavy-duty
HEV	Hybrid electric vehicle
HHEA	Hybrid hydraulic-electric architecture
HIL	Hardware-in-the-loop
HPDI	High-pressure direct injection

Abbreviation	Definition
ICE	Internal combustion engine
ID	Identification
ID	Ignition delay
LDI	Lean direct injection (LDI)
LES	Large eddy simulation
LLCF	Low-lifecycle-carbon-fuels
LLNL	Lawrence Livermore National Laboratory
MAN	MAN Energy Solutions
MCCI	Mixing-controlled compression ignition
MD	Medium-duty
MeOH	Methanol
N_2O	Nitrous oxide
NASA	National Aeronautics and Space Administration
NG	Natural gas
NH_3	Ammonia
NH_4NO_3	Ammonium nitrate
NJFCP	National Jet Fuel Combustion Program
NO	Nitric oxide
NO_2	Nitrogen dioxide
NO_x	Nitrogen oxides
NREL	National Renewable Energy Laboratory
NSF	National Science Foundation
O_3	Ozone
OEM	Original equipment manufacturer
OP2S	Opposed piston, two stroke
ORNL	Oak Ridge National Laboratory
Pd	Palladium
PGM	Platinum group metals
PIV	Particle image velocimetry
PNA	Polynuclear aromatics
PNNL	Pacific Northwest National Laboratory

Abbreviation	Definition
Pt	Platinum
R&D	Research and development
RDD&D	Research, development, deployment, and demonstration
Rh	Rhodium
RNG	Renewable natural gas
RQL	Rich-quench-lean (RQL) combustor
Ru	Ruthenium
RuO_2	Ruthenium oxide
SAE	SAE International, formerly known as the Society of Automotive Engineers
SAF	Sustainable aviation fuel
SATF	Synthetic aviation turbine fuel
SCE	Combination of simulation and experiments
SCR	Selective catalytic reduction
SCRE	Single-cylinder research engine
SHA	Single-hole atomizer
Si/Al	Silicon/aluminum
SiC	Silicon carbide
SNL	Sandia National Laboratories
SRM	Stochastic Reactor Model
SULEV30	Super-ultra-low emissions vehicle 30 standard
SwRI	Southwest Research Institute
TWC	Three-way catalyst
UIUC	The University of Illinois Urbana-Champaign
ULEV	Ultra-low emissions vehicle
USA	United States of America
VTO	Vehicle Technologies Office
WHR	Waste heat recovery
WVU	West Virginia University

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4. Energy Efficient Mobility Systems

The Vehicle Technologies Office (VTO) supports research, development, demonstration, and deployment (RDD&D) of new, efficient, and clean mobility options that are affordable for all Americans. The office's investments leverage the unique capabilities and world-class expertise of the national laboratory system to develop new innovations in vehicle technologies, including: advanced battery technologies; advanced materials for lighter-weight vehicle structures and better powertrains; energy-efficient mobility technologies and systems (including automated and connected vehicles as well innovations in connected infrastructure for significant systems-level energy efficiency improvement); innovative powertrains to reduce greenhouse gas (GHG) and criteria emissions from hard to decarbonize off-road, maritime, rail, and aviation sectors; and technology integration that helps demonstrate and deploy new technology at the community level. In coordination with the other offices across the Office of Energy Efficiency and Renewable Energy (EERE) and the U.S. Department of Energy (DOE), VTO advances technologies that assure affordable, reliable mobility solutions for people and goods across all economic and social groups; enable and support competitiveness for industry and the economy/workforce; and address local air quality and use of water, land, and domestic resources.

The Energy Efficient Mobility Systems (EEMS) subprogram supports RDD&D of innovative mobility solutions that improve the affordability, accessibility, and energy productivity of the overall transportation system. EEMS leverages emerging disruptive technologies such as connected and automated vehicles, information-based mobility-as-a-service platforms, and artificial intelligence-based transportation control systems to accelerate the transition to a zero carbon-emission transportation future. The EEMS subprogram also develops and utilizes large-scale transportation modeling and simulation capabilities to evaluate the impacts of new mobility solutions across multiple geographies and populations, ensuring that all Americans, especially underserved populations and energy communities, benefit from the development and deployment of clean transportation technologies.

The EEMS subprogram consists of two primary activities: Computational Modeling and Simulation, and Connectivity and Automation Technology. The subprogram's overall goal is to identify feasible system-level pathways and develop innovative technologies and systems that can dramatically improve mobility energy productivity for individuals and businesses when adopted at scale. The EEMS subprogram has developed a quantitative metric for mobility energy productivity, which measures the affordability, energy efficiency, convenience, and economic opportunity derived from the mobility system. The metric, while encompassing multiple vehicle classes and modes for passenger and goods movement, is used by the subprogram to evaluate success and by the transportation community to inform planning decisions. The EEMS subprogram's target is a 20% improvement in mobility energy productivity by 2040 relative to a 2020 baseline.

Project Feedback

In this merit review activity, each reviewer was asked to respond to a series of questions, involving multiple-choice responses, expository responses where text comments were requested, and numeric score responses (on a scale of 1.0 to 4.0). In the pages that follow, the reviewer responses to each question for each project will be summarized: the multiple choice and numeric score questions will be presented in graph form for each project, and the expository text responses will be summarized in paragraph form for each question. A table presenting the average numeric score for each question for each project is presented below.

Table 4-1 – Project Feedback

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
EEMS013	ANL Core Tools-Simulation	Phil Sharer (Argonne National Laboratory)	4-7	3.20	3.30	3.20	3.10	3.24
EEMS041	ANL Everything-in-the-loop (XIL) Capabilities	Kevin Stutenberg (Argonne National Laboratory)	4-11	3.50	3.63	3.75	3.63	3.61
EEMS066	Livewire Data Platform-A Solution for Energy Efficient Mobility Systems (EEMS) Data Sharing	Lauren Spath-Luhring (National Renewable Energy Laboratory)	4-14	3.50	3.38	3.50	3.38	3.42
EEMS089	Energy Efficient CAVs, Workflow Development and Deployment	Dominik Karbowski (Argonne National Laboratory)	4-17	3.75	3.63	3.88	3.67	3.69
EEMS090	Applying Artificial Intelligence (AI) Based Signal Coordination and Controls for Optimized Mobility for the Nimitz Highway	Hong Wang (Oak Ridge National Laboratory)	4-20	3.25	3.13	3.50	3.25	3.22
EEMS092	BEAM CORE	Anna Spurlock (Lawrence Berkeley National Laboratory)	4-23	3.00	3.10	3.30	3.10	3.10
EEMS093	Transportation System Impact, POLARIS Workflow Development, Implementation and Deployment	Joshua Auld (Argonne National Laboratory)	4-28	3.50	3.75	3.8	3.50	3.67

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
EEMS094	Development and Validation of Intelligent Connected and Automated Vehicle (CAV) Controls for Energy-Efficiency	Dominik Karbowski (Argonne National Laboratory)	4-32	3.30	3.40	3.60	3.20	3.38
EEMS095	Integrated Control of Vehicle Speeds and Traffic Signals for Reducing Congestion and Energy Use	Jinghui Yuan (Oak Ridge National Laboratory)	4-37	2.58	2.67	3.42	2.33	2.70
EEMS096	Characterizing Behaviors and Capabilities for Emerging Connected and Automated Vehicle Technologies and Sensors	Thomas Wallner (Argonne National Laboratory)	4-42	3.00	3.10	3.20	2.90	3.06
EEMS097	Micromobility-Integrated Transit and Infrastructure for Efficiency (MITIE)	Andrew Duvall (National Renewable Energy Laboratory)	4-47	3.60	3.60	3.50	3.40	3.56
EEMS098	Optimizing Drone Deployment for More Effective Movement of Goods	Victor Walker (Idaho National Laboratory)	4-51	3.25	3.38	3.50	3.13	3.33
EEMS099	Metrics for Assessing the Impacts of Energy-Efficient Mobility Systems (EEMS)	Venu Garikapati (National Renewable Energy Laboratory)	4-55	3.67	3.50	3.67	3.67	3.58
EEMS100	Dynamic Curb Allocation	Nawaf Mohammed (Pacific Northwest National Laboratory)	4-58	2.90	2.90	3.00	2.60	2.88
EEMS101	RealSim, An Anything-in-the-loop Platform for Mobility Technologies	Yunli Shao (Oak Ridge National Laboratory)	4-63	3.63	3.88	3.63	3.63	3.75
EEMS102	AI-Engine for Optimizing Integrated Service in Mixed Fleet Transit Operations	Philip Pugliese (Chattanooga Area Regional Transportation Authority)	4-66	3.10	3.20	3.30	3.00	3.16

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
EEMS103	Transit-Centric Smart Mobility System for High-Growth Urban Activity Centers, Improving Energy Efficiency through Machine Learning	Jinhua Zhao (Massachusetts Institute of Technology)	4-70	3.25	3.38	3.38	3.25	3.33
EEMS104	Increasing Affordability, Energy Efficiency, and Ridership of Transit Bus Systems through Large-Scale Electrification	Ziqi Song (Utah State University)	4-73	3.40	3.30	3.30	3.10	3.30
EEMS105	Energy Optimization of Light and Heavy Duty Vehicle Cohorts of Mixed Connectivity, Automation and Propulsion System Capabilities via Meshed V2V-V2I and Expanded Data Sharing	Darrell Robinette (Michigan Technological University)	4-77	3.50	3.30	3.20	3.00	3.30
EEMS106	Developing an Energy-Conscious Traffic Signal Control System for Optimized Fuel Consumption in Connected Vehicle Environments	Mina Sartipi (University of Tennessee)	4-82	2.90	3.10	3.50	2.90	3.08
EEMS107	Improving network-wide fuel economy and enabling traffic signal optimization using infrastructure and vehicle-based sensing and connectivity	Joshua Bittle (University of Alabama)	4-87	2.90	3.10	3.10	2.90	3.03
EEMS108	Co-Optimization of Vehicles and Routes	Nick Hertlein (PACCAR)	4-92	2.70	2.80	2.90	2.80	2.79
EEMS109	Connected and Learning Based Optimal Freight Management for Efficiency	Ali Borhan (Cummins)	4-96	3.50	3.50	3.40	3.30	3.46

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
EEMS110	Human Factors and Technologies Design to Improve User Acceptance of Pooled Rideshare (PR) for Increasing Transportation System Energy Efficiency	Yunyi Jia (Clemson University)	4-100	3.38	3.63	3.63	3.38	3.53
EEMS111	Contextual Predictions and Eco Services for Electrified Vehicles	Jacopo Guanetti (AV-Connect, Inc.)	4-104	2.88	2.88	2.75	2.83	2.85
EEMS112	NREL Core Modeling & Decision Support Capabilities (RouteE, FASTSim, OpenPATH, T3CO)	Jeff Gonder (National Renewable Energy Laboratory)	4-108	3.00	3.20	3.40	3.00	3.15
EEMS113	Testing and Evaluation of Curb Management and Integrated Strategies to Catalyze Market Adoption of Electric Vehicles	Lauren Harper (Los Angeles Cleantech Incubator)	4-112	3.38	3.38	3.38	3.38	3.38
EEMS114	Real Twin	Yunli Shao (Oak Ridge National Laboratory)	4-116	3.33	3.00	3.00	3.00	3.08
EEMS115	Modeling Connected and Automated Vehicles (CAV) Compute Power	Ben Feinberg (Sandia National Laboratories)	4-119	2.75	2.88	2.63	2.88	2.81
EEMS116	High-Quality Perception Data	Zach Asher (Western Michigan University)	4-122	3.25	3.25	3.13	3.25	3.23
EEMS117	Visual-Enhanced Cooperative Traffic Operations (VECTOR) System	Cami Qianwen (University of South Florida)	4-126	2.83	2.83	3.33	2.83	2.90
EEMS118	AI-Based Mobility Monitoring System and Analytics Demonstration Pilot	Scott Samuelson (University of California, Irvine)	4-129	2.75	3.25	3.00	2.88	3.05

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaboration	Future Research	Weighted Average
EEMS119	Improved Mobility and Energy Savings Through Optimization of Cooperative Driving Automation (CDA) Application for Signal Controls for Arterial Mixed Traffic Scenarios	Xiao-Yun Lu (Lawrence Berkeley National Laboratory)	4-133	3.50	3.00	3.17	3.33	3.19
EEMS120	A Cooperative Driving Automation (CDA) Framework for Communications	Adian Cook (Oak Ridge National Laboratory)	4-136	3.30	3.00	3.20	3.10	3.11
EEMS121	Decentralized and Cooperative Traffic Signal Network for Freight Energy Efficiency, Safety, Sustainability, and Public Health	Michael Lim (Xtelligent)	4-140	3.25	3.00	3.38	3.25	3.14
Overall Average				**3.21**	**3.24**	**3.33**	**3.14**	**3.23**

Presentation Number: EEMS013
Presentation Title: ANL Core Tools-Simulation
Principal Investigator: Phil Sharer (Argonne National Laboratory)

Presenter

Phil Sharer, Argonne National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

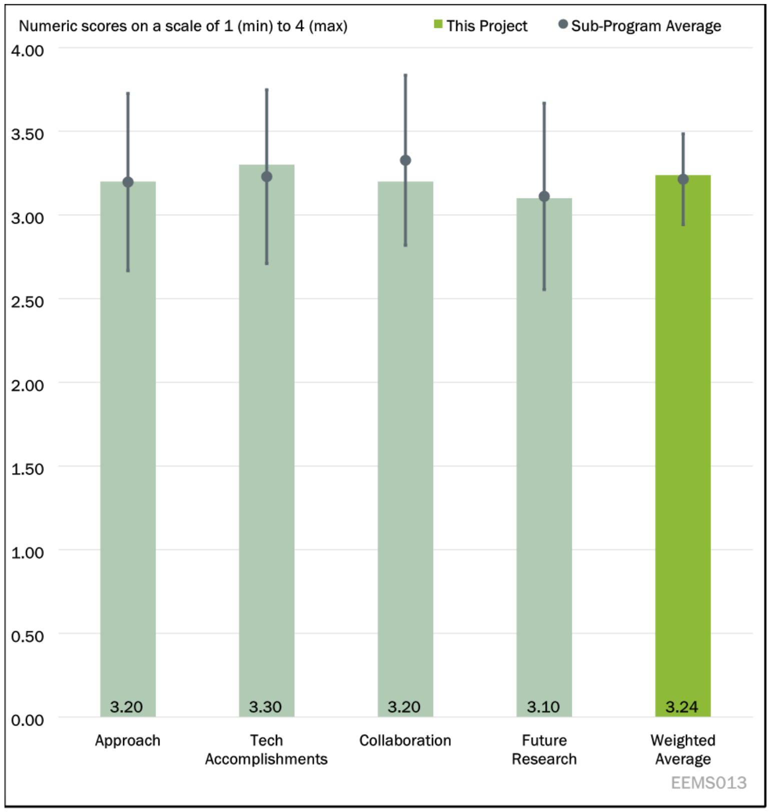

Figure 4-1 - Presentation Number: EEMS013 Presentation Title: ANL Core Tools-Simulation Principal Investigator: Phil Sharer (Argonne National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer stated that the approach to modeling and tool development is sound with Advanced Model Based Engineering Resource (AMBER) being used as a framework for model-based systems engineering workflows and with ongoing integration of data and inputs from public and private sources.

Reviewer 2:

The reviewer commented that the work approach is solid. The remaining challenges are non-trivial and overcoming them is essential to achieving the intended outcome. Work should prioritize usability of the software over chasing precision.

Reviewer 3:

The reviewer stated that the project addresses all technical barriers, is well designed with a well-planned timeline.

Reviewer 4:

The reviewer commented that the technical barriers were addressed and described sufficiently. There were plans for overcoming them, noting the uncertainty involved in some cases. This indicates a well-designed project and milestone plan. Integrating and synchronizing metadata from various files is a significant undertaking which will accelerate future progress, as well as make the final product(s) more user friendly. It is unclear how updated version releases of the subcomponent software applications will be handled to sustain future support and enhancements.

Reviewer 5:

This reviewer described the work as more academic and less industrial oriented.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer noted that Autonomie AI and Aeronomie are new developments allowing faster computation and non-traditional battery electric vehicle (BEV) architecture studies.

Reviewer 2:

The reviewer commented that clear progress has been made across the areas. Consistent with work approach, overcoming the remaining barriers must be the dominant priority moving forward.

Reviewer 3:

The reviewer stated that this project demonstrated good technical progress.

Reviewer 4:

The reviewer noted that the progress, in comparison to the plan timeline, appears to be excellent. This is largely due to the extensive effort in stakeholder outreach. The complex nature of the work, with an eye toward anticipated users helps ensure buy-in from stakeholders, more licenses to support future maintenance and product implementation and adoption.

Reviewer 5:

The reviewer said that there was scattered incremental progress.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer observed that "Core” tools are tightly integrated across multiple projects and government agencies such as National Highway Traffic Safety Administration (NHTSA), Driving Research and Innovation for Vehicle Efficiency and Energy Sustainability (U.S. DRIVE), EcoCAR, 21st Century Truck Partnership (21CTP), etc.

Reviewer 2:

The reviewer commented that the projects are clearly coordinated across projects. The interdependence can be a problem as the embedding, layering, and handoff compounds errors and uncertainties that inherently and naturally exist in models. More emphasis needs to be on ensuring the usefulness of the models vs. complexity.

Reviewer 3:

The reviewer stated that this project has well planned collaboration and coordination across its members.

Reviewer 4:

The reviewer observed that the presentation demonstrated a significant collaboration with various vendors, data sources, other national laboratories, DOT NHTSA and industry. It is good to cite related VTO projects and which ones this project supports. It would be helpful to list the projects and the specific links in objectives between them. The reviewer is not sure if or why there was not interaction with DOT/FHWA because of their previous and planned investments in electrification through charging corridors Federal Aviation Administration (FAA) because of airspace regulation, and the Federal Railroad Administration (FRA) because of railroad regulation. Also, the American Association of State Highway and Transportation Officials (AASHTO) and interaction with the National Academies would be good objective criticism and exposure and perhaps participation/assistance from some state highway agencies.

Reviewer 5:

The reviewer commented that close collaboration amongst partners is not visible and there is uncoordinated independent research and results.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer commented that the proposed future research involving extensions to other transportation modes and incorporating very large datasets is well-motivated and will be useful when completed.

Reviewer 2:

The reviewer said the proposed work is what should be expected but does not offer any remarkable or breakthrough ideas.

Reviewer 3:

The reviewer noted that the proposed future research is clearly defined, will likely achieve its targets.

Reviewer 4:

The reviewer commented that the future research in terms of aviation and rail are ambitious. Since the design and operational parameters are highly proprietary and there are strict regulations in place that must be considered, these potential barriers could hinder future research with the funding and timeline available. Assuming revenue from the licensees and federal agencies involved, the continued stakeholder outreach and expanded outreach to standards organizations, like AASHTO, it may be possible.

Reviewer 5:

The reviewer said that a re-assessment of original goals and assessment of gaps/resources might be valuable. It requires consideration for a zero-emission future transportation that could challenge the potential application of the outcome of this research applicable to internal combustion engines or plug-in hybrid transportation.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer stated that the tools and datasets developed as a result of this project will be very useful for setting the policy and developing strategies for carbon dioxide (CO_2) reduction in future years.

Reviewer 2:

The reviewer noted that as established projects, each project has a history of supporting the VTO subprogram objectives. The merit of those objectives is a separate question.

Reviewer 3:

The reviewer said that this project supports VTO project objectives very well.

Reviewer 4:

The reviewer commented that the project is highly relevant to the VTO subprogram objectives, and they appropriately cite related projects. If these projects are encouraged to share expertise and resources, the chances of success are improved. It would also be helpful for the VTO office representative overseeing this project make an effort to coordinate with other agencies (e.g., DOT) to see where interests overlap and where resources (funding, facilities, data, etc.) may be shared symbiotically. There should be funding available through the Bipartisan Infrastructure Law (BIL) and the Inflation Reduction Act (IRA) to support this research.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented that this is a broad and comprehensive activity and the allocated funds of $5.4 million ($3.6 million received) from October 2021 to September 2024 are just right to get the tasks done.

Reviewer 2:

The reviewer said that overall, the resources are sufficient. Moving forward, the program should look to ways to reduce the financial resources needed and set clearer timelines and more specific goals for the funding allocated.

Reviewer 3:

The reviewer noted that provided the total funding is provided, the stated milestones should be achievable based on current progress. However, additional time and funding will be required for the recommended future research.

Reviewer 4:

The reviewer said that funding is sufficient but appears uncoordinated.

Presentation Number: EEMS041
Presentation Title: ANL Everything-in-the-loop (XIL) Capabilities
Principal Investigator: Kevin Stutenberg (Argonne National Laboratory)

Presenter

Kevin Stutenberg, Argonne National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

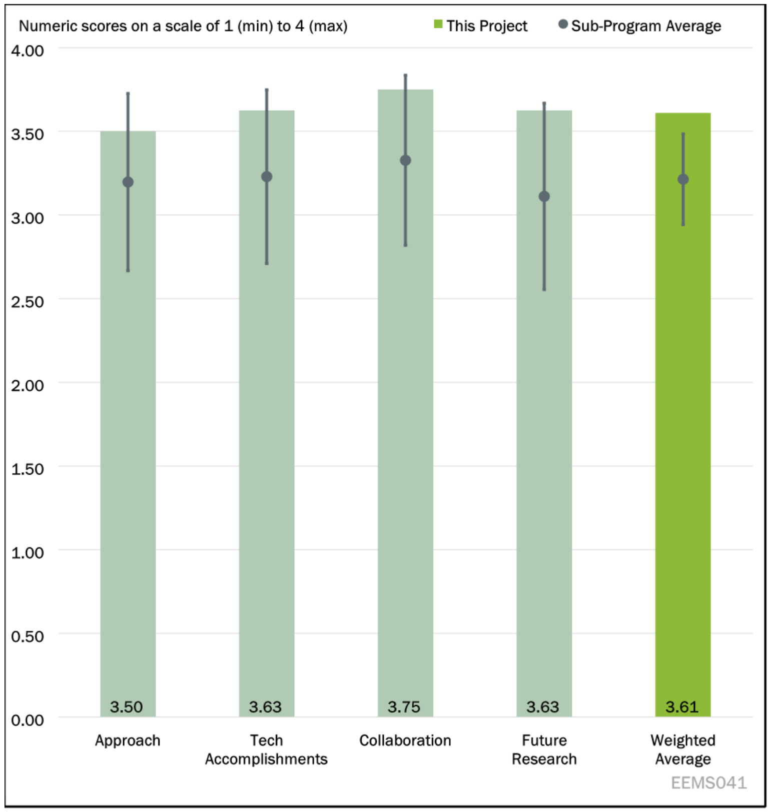

Figure 4-2 - Presentation Number: EEMS041 Presentation Title: ANL Everything-in-the-loop (XIL) Capabilities Principal Investigator: Kevin Stutenberg (Argonne National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer commented that there is an intrinsic difficulty in trying to get the fundamental information that underpins this research since original equipment manufacturers (OEMs) are very proprietary about their system data and behavior. This is a difficult barrier to overcome.

Reviewer 2:

The reviewer commented that the project addresses all technical barriers, well designed and well planned.

Reviewer 3:

The reviewer stated that there was an excellent integration of experimental, modeling and controls. Good progress has been made on all the objectives. The researchers understand issues with vehicle complexity, ability to manipulate vehicle controls, and that OEM support will likely be necessary going forward.

Reviewer 4:

The reviewer stated that the approach of everything-in-the-loop (XIL) is a very good approach to reduce closed track testing and allows for controlled environment and conditions. Track testing is time and money consuming. Excellent vision to setup this project and other complimentary DOE projects to support the XIL initiative.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer commented that the team has done a tremendous job in getting the data with ingenious workarounds. The virtual vehicle-to-everything (V2X) work is quite impressive.

Reviewer 2:

The reviewer noted that the progress is good, but it is only 30% done. Good new vehicles are to be included (this year: Ford F150 Lightning, Cadillac Lyriq, Fiscal Year (FY) 2024: Additional two new XIL research vehicles), which is good.

Reviewer 3:

The reviewer stated that the extensive development and integration is complete demonstration of integrated controls with virtual scenarios. The reviewer was unclear on the ten multi-vehicle scenarios completed whether these were "virtual" vehicles or data recorded from real vehicles. A need going forward is to have realistic, probabilistic interaction with vehicles, traffic, and uncertainty in inputs and signals. If utilizing virtual vehicles, the reviewer suggested specifying what driver model is used and whether in the micro traffic scenarios it is representative of human and other connected and automated vehicles (CAVs).

Reviewer 4:

The reviewer said that the ability to have the dynamometer adjust road grade to the profile of real-world road and infrastructure is an awesome feature that will aid in future CAV research and testing.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer said there is a great mix of university, government laboratories and agencies. The reviewer commented that the team would be improved with some sort of OEM collaboration but realizes that this is difficult to arrange.

Reviewer 2:

The reviewer noted that the collaboration and coordination is well planned.

Reviewer 3:

The reviewer commented that there was excellent coupling and coordination between hardware, controls and software teams.

Reviewer 4:

The reviewer noted there was great collaboration with other national laboratories and universities.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer commented that the next steps are meaningful to advancing XIL research capabilities. With increased OEM concern about hacking cars, it seems there is a risk of the work becoming more difficult with ever increasing security measures.

Reviewer 2:

The reviewer commented that the proposed future research is well planned and will very likely achieve its targets.

Reviewer 3:

The reviewer stated that the integration of XIL research vehicles is a good selection. The team has commitments from OEMs for assistance which is important going forward. With respect to XIL workflow, possible to data mine the DOE EEMS projects for road data.

Reviewer 4:

The inclusion of newer vehicles—such as the Ford F150 Lightning and Cadillac Lyriq—was mentioned in the context of hurdles of getting connectivity to the vehicle controls. The inclusion of lateral loading will help in fully representing the dynamics of the vehicle but is not sure if it will lead to more accurate energy consumption relative to longitudinal dynamics, but nonetheless, will make the whole of XIL more representative. It would be really neat to see distributed XIL demonstration of multiple laboratory locations and vehicles operating cooperatively connected to the XIL platform.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer noted that the project is highly relevant to quantifying performance of V2X technologies which is a key technology research area.

Reviewer 2:

The reviewer commented that this project supports the VTO objectives very well.

Reviewer 3:

The reviewer believes that this project supports the overall VTO EEMS subprogram.

Reviewer 4:

The reviewer commented that this project and related ones will help in making the case to OEMs to develop cooperative connected control and automation to reduce fuel consumption. Without all OEMs getting onboard the fleet would not get there, thus this and associated projects will help steer legislation that incentivizes OEMs to work towards hardware and software that will enable functionality across multiple vehicle brands.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said resources appear adequate. The work is on schedule and on budget.

Reviewer 2:

The reviewer commented that the resources are well aligned with the project.

Reviewer 3:

The reviewer stated that yes, the project has sufficient computer, software, vehicle, dynamometer, measurement, and road/closed track facilities to execute with the necessary instrumentation and vehicle interfacing abilities to conduct the work on time and budget.

Presentation Number: EEMS066
Presentation Title: Livewire Data Platform-A Solution for Energy Efficient Mobility Systems (EEMS) Data Sharing
Principal Investigator: Lauren Spath-Luhring (National Renewable Energy Laboratory)

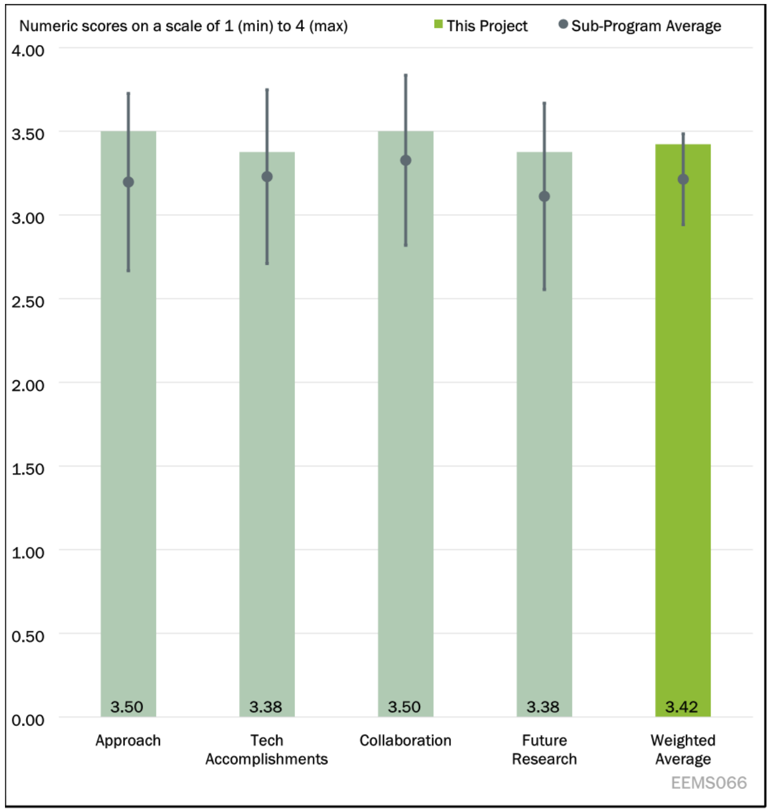

Figure 4-3 - Presentation Number: EEMS066 Presentation Title: Livewire Data Platform-A Solution for Energy Efficient Mobility Systems (EEMS) Data Sharing Principal Investigator: Lauren Spath-Luhring (National Renewable Energy Laboratory)

Presenter

Lauren Spath Luhring, National Renewable Energy Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 25% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer commented that the Livewire project approach focuses on platform development and security, data quality characterization, catalog growth and user support. These are all excellent focus areas for this type of work.

Reviewer 2:

The reviewer said that initiated in 2019, the Livewire Data Platform (LDP) provides for the sharing, preserving, and discovering of energy efficiency and mobility research data. The basic approach is to build off other successful data platforms focusing upon platform development and security, data quality characterization, catalog growth, and user support. The Livewire Data Working Group (DWG) was established in 2021 to provide a forum for feedback and input from data owners and data users, which is good. Overall, a reasonable approach. A fundamental deficiency is the lack of robust metrics to truly assess the “value” and return on investment of the LDP. The present metrics, such as number of projects, users, datasets, and files stored do not truly assess “value.”

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer noted that the Livewire team has accomplished the following: (1) self-service data upload capability; (2) user access validation for privileged data; (3) whitepaper publication, describing platform enhancements; (4) development of reference document categories; and, (5) publication of detailed metadata and quality characterization for 32 datasets and several additional noteworthy deliverables.

Reviewer 2:

The reviewer stated that the technical accomplishments and progress outlined in their presentation qualifies them for "outstanding" scoring.

Reviewer 3:

The reviewer said that during the past year, the project has achieved an acceptable list of technical accomplishments, mostly information technology related in nature. These include self-service upload capability, validation of user access to Tier 3 datasets, and addition of reference document categories. Most importantly was the accomplishment that the LDP was enabled to support cross-federation of datasets to/from other similar catalogs (e.g., DOT's data.transportation.gov). Overall, however, accomplishments specifically enhancing hard value appear to be lacking.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer commented that Livewire is based on a strong collaboration between Idaho National Laboratory (INL), NREL, and Pacific Northwest National Laboratory (PNNL), plus partnerships with EEMS Systems and Modeling for Accelerated Research in Transportation (SMART), and VTO Technology Integration (TI) subprogram.

Reviewer 2:

The reviewer stated that the Livewire platform interface and quality demonstrates the coordination and integration between teams. Similarly, the variety of datasets hosted by it. Indeed, our performer used this platform for one of our program projects.

Reviewer 3:

The reviewer noted that the project team is sound incorporating three national laboratories and solid communications/coordination with the EEMS research community, VTO-funded funding opportunity announcement (FOA) awardees, and mobility researchers. Data has been incorporated from more than 60 organizations, DOE, national laboratories, and many research partners. Consideration of industry involvement may be good to gain additional insights, perspectives, and recommendations.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer commented that the future research plan is sound, including (1) development of a pipeline to standardize and curate metadata and data; (2) elimination of manual processes for creating and submitting high level metadata; (3) distribution of a quarterly email newsletter re: updates; (4) data quality analysis; and, (5) demonstration of growth and continued impact of NREL's Transportation Secure Data Center (TSDC) and Fleet DNA tool.

Reviewer 2:

The reviewer stated that there does not seem to be a robust plan for making this platform/data available and helpful to other researchers outside EEMS, much less to practitioners in the field. The reviewer understands this is a relatively new aspect of the work, but this seems to be a critical area that needs more focus and attention. Simply creating a periodic newsletter and asking people to forward it is not a strategy. The reviewer would like to see a fully developed marketing and communication plan that includes proactive outreach to transportation researchers, academics, consulting firms, industry, local transportation planners, other NGOs, and more.

Reviewer 3:

The reviewer noted that it is integral for enhancing the full capabilities of the platform.

Reviewer 4:

The reviewer very much liked the proposed future research with regards to the “data analysis center.” This could enhance interest, user-friendliness, and overall impact. Moving forward it is recommended that the LDP work to enhance its value and return on investment. Consideration could be given to several items including (1) identifying / instituting new metrics to more accurately determine the value of the LDP; (2) enhancing the utilization of the DWG; (3) instituting requirements for cost share; and, (4) consideration of migration of the LDP to an industry host for further development, management, and user support.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer commented that this data is key to modeling studies on transportation, mobility, and CO_2. Hence Livewire plays a key role towards achieving the overall VTO program objectives.

Reviewer 2:

The reviewer commented that yes, it does have relevance.

Reviewer 3:

The reviewer noted that in general, there is a need for a secure, accessible data repository to facilitate the RDD&D of advanced transportation technologies. This can accelerate the pace of RDD&D and leverage/lead to more expeditious use of funds.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that the allocated budget of $5.1 million over approximately 3 years is just right for the list of milestones planned for Livewire.

Reviewer 2:

The reviewer commented that the funding resources for this project seem excessive and there is no cost share. Consideration could be given to requirements for cost share for project continuation.

Reviewer 3:

The reviewer commented that yes, the resources are sufficient.

Presentation Number: EEMS089
Presentation Title: Energy Efficient CAVs, Workflow Development and Deployment
Principal Investigator: Dominik Karbowski (Argonne National Laboratory)

Presenter

Dominik Karbowski, Argonne National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

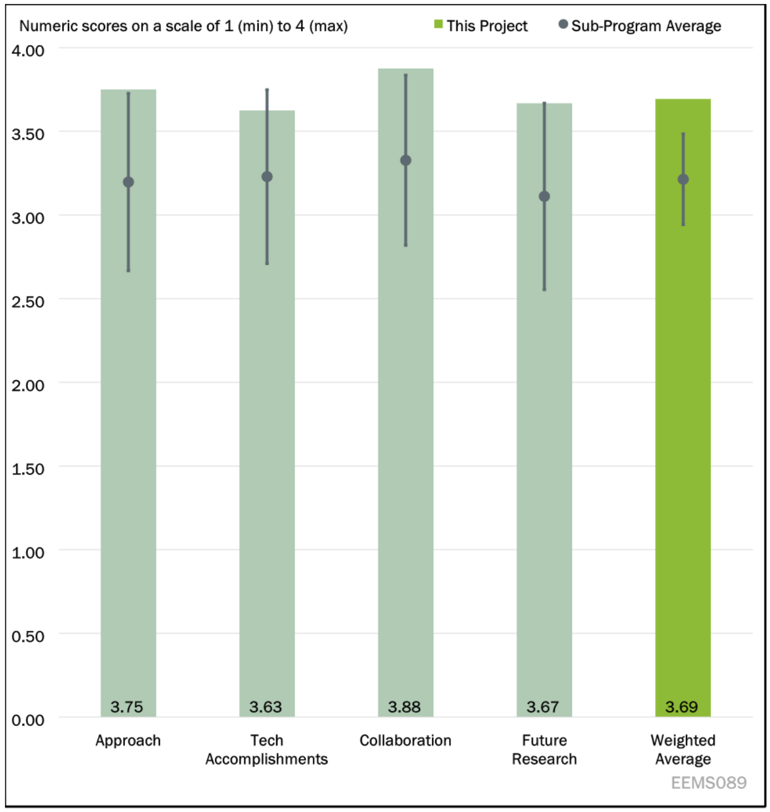

Figure 4-4 - Presentation Number: EEMS089 Presentation Title: Energy Efficient CAVs, Workflow Development and Deployment Principal Investigator: Dominik Karbowski (Argonne National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer stated that the project is very effective, showing excellent progress in addressing tech barriers in a well-planned timeline.

Reviewer 2:

The reviewer stated that the work performed by lead and partner organizations related to models, workflows, and software has been performed in a logical manner and takes advantage of the strengths of each partner/collaborator. The integration of Development and Validation of Intelligent CAV Controls for Energy Efficiency (EEMS094), Argonne National Laboratory (ANL) Core Tools-Simulation (EEMS013), and ANL everything-in-the-loop (XIL) Capabilities (EEMS041), into this program seems to optimize the project’s timeline.

Reviewer 3:

The reviewer commented that the approach is outstanding.

Reviewer 4:

The reviewer said the approach is strong and links together four other EEMS projects, pulls in other national laboratories and vehicle OEMs. The technical approach to CAV workflow is solid.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer commented that the project has excellent developments, all according to the plan.

Reviewer 2:

The reviewer said that most of the work is finalized, so this shows that the team was able to overcome barriers and produce the needed outcomes. Note that the comment made about developing a human model based on Hyundai's data is not trivial, this model needs to be validated with other vehicles and types of drivers in future projects to ensure it is representative of the current driving population.

Reviewer 3:

The reviewer said that the technical accomplishments and progress are outstanding.

Reviewer 4:

The reviewer said that the team has accomplished significant milestones and technical works. Of particular interest is the AI vehicle speed prediction for vehicle profiling and the deployment of the human driver model to an OEM. The demonstrations of CAVs under virtual traffic conditions are a great step for XIL on a dynamometer.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer noted that the collaboration and coordination across the project team is excellent.

Reviewer 2:

The reviewer commented that the project having General Motors (GM)/Nissan as stakeholders is important given the need for use and validation of the developed products/deliverables of these projects. For further projects, it would be important to have a larger stakeholder group for feedback on validation and implementation.

Reviewer 3:

The reviewer said that the collaboration and coordination across the project team was outstanding.

Reviewer 4:

The reviewer commented that the team has pulled in all the right stakeholders to maximize project outcomes, from other national laboratories to vehicle OEM's who are actually taking and utilizing project technical work and tools.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer believes that the project has good plan on the future research.

Reviewer 2:

The reviewer said that it meets the expectation of what will occur at the conclusion of the project and including additional scenarios and an additional validation of a CAV model.

Reviewer 3:

The reviewer stated that the proposed future research is outstanding.

Reviewer 4:

The reviewer said that no future research was discussed in the released materials or during the presentation given the project is close to the end of its period of performance.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer said that yes, it is a very good match with the VTO objectives.

Reviewer 2:

The reviewer commented that this is a very relevant project for VTO. Future projects to expand the different capabilities of the models, workflow, and software should branch out into other types of vehicles to ensure mobility is optimized (i.e., heavy vehicles).

Reviewer 3:

The reviewer stated that this project in combination with other EEMS is an integrated approach to showing how connectivity and automation can reduce energy consumption and improve traffic throughput all while trying to do it without costly and time-consuming closed test track testing—all pillars of what VTO is about.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer believes that the resources are sufficient.

Reviewer 2:

This project will end in September 2023. The funding allocation for the project seemed reasonable and sufficient given it takes advantage of several other related projects.

Reviewer 3:

The reviewer commented that the resources are sufficient and well spread out between collaborating partners. It is great to see what Clemson University was able to do with the digital twin and virtual track demonstration.

Reviewer 4:

The reviewer commented that the resources are sufficient.

Presentation Number: EEMS090
Presentation Title: Applying Artificial Intelligence (AI) Based Signal Coordination and Controls for Optimized Mobility for the Nimitz Highway
Principal Investigator: Hong Wang (Oak Ridge National Laboratory)

Presenter

Hong Wang, Oak Ridge National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

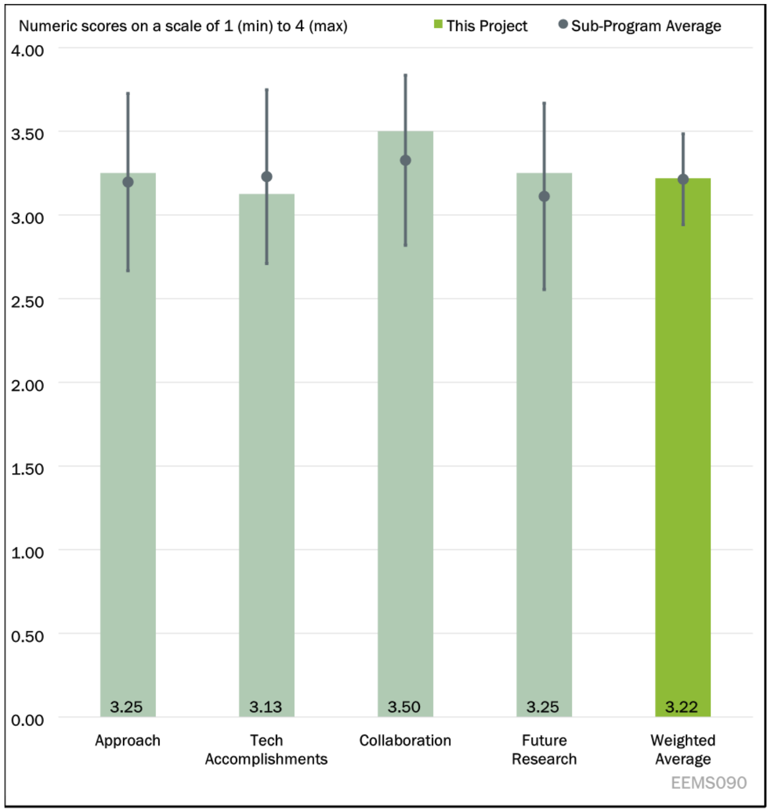

Figure 4-5 - Presentation Number: EEMS090 Presentation Title: Applying Artificial Intelligence (AI) Based Signal Coordination and Controls for Optimized Mobility for the Nimitz Highway Principal Investigator: Hong Wang (Oak Ridge National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer noted that the project is mostly complete, most testing has been completed, but is still awaiting some longer-term, whole system testing. The project uses AI to make better control algorithms for traffic flow. The energy model is based on fleet average, could these be leveraged to prioritize higher-emitting vehicle types or other goals (e.g., prioritize public transit weight times with potentially more passengers than personal/light duty vehicles)?

Reviewer 2:

The reviewer commented that considering that the only available information for this review is the presentation slides it is hard to understand how technical barriers were addressed. It is unclear from the presentation how the neural network (NN) was implemented in the process. The reviewer understands the role of the offline optimization through the microsimulation which produces optimal split is for the fixed cycle length, but it is not clear what nodes the NN control in real-time. Regardless, given that the project is almost complete, timeline was reasonably planned, and difficulties encountered were handled successfully.

Reviewer 3:

The reviewer noted that the project is 90% complete and is not listing remaining issues and need to complete remaining work.

Reviewer 4:

The reviewer indicated that the approach is acceptable and met the objectives.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer stated that the team has completed the design of the algorithm and has completed several multi-day tests.

Reviewer 2:

The reviewer believed that as the project plan is assumed from the presentation, technical progress was steady and effective.

Reviewer 3:

The reviewer stated that the optimization of traffic flow is good. The energy saved estimation is very simplistic, but it is also good to evaluate the benefit of this project. BEV, Hybrid, and internal combustion engine (ICE) will all have different energy savings value to rate against the optimization of flow, but that is not likely needed here as the optimization of flow will likely be the dominant factor weighted against any balance of fleet.

Reviewer 4:

The reviewer noted that the project has good results.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer stated that the project team includes industry, university, and national laboratory partners. Industry support has provided computational resources and control technology of traffic lights to allow research to focus on developing algorithms/control strategies.

Reviewer 2:

The reviewer commented that the project has collaborations between industry, government, a national laboratory, and academia. The project performance and accomplishments show a very good coordination between the different actors.

Reviewer 3:

The reviewer noted that the oral presentation was handed off between partners well. The University of Hawaii with ORNL look to be completing the work together and on time.

Reviewer 4:

The reviewer expressed interest in seeing it applied to larger urban areas and a variation of drive conditions.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer reported that the project is nearly complete, with some final testing to be performed ahead of licensing of technology by industry partner. Project resources are in place to complete the longer-scale testing.

Reviewer 2:

The reviewer stated that no description of future research was offered.

Reviewer 3:

The reviewer noted that the project is past 90% complete.

Reviewer 4:

The reviewer suggested it needs to be tested in different urban areas for further applications.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer noted that the project is aligned with program objectives to use AI/machine learning (ML) methods to improve the efficiency of the overall traffic system. By developing and implementing algorithms that are able to take real-time data inputs and appropriately time traffic lights, they are able to reduce the wait times of vehicles at intersections, reducing idling time.

Reviewer 2:

The reviewer commented that traffic control is necessary for the safe and efficient operation of a road network. There is not a single optimal solution since it is impossible to know each individual’s cost in energy and time. Any methodology that utilizes available traffic data and given the level of information provides even a local optimal solution that is capable of adapting in the changing nature of traffic has the promise of gains. Therefore, this project is extremely relevant to operational improvement of current traffic control methodologies and technologies. Given that the methodology is utilizing AI, the reviewer felt researchers did not really learn anything new regarding the traffic system, therefore when new data sources and technologies become available the exercise will need to be repeated.

Reviewer 3:

The reviewer stated that the project looks to integrate future transportation technologies and reduce overall vehicle fleet energy use.

Reviewer 4:

The reviewer noted real world applications.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer believed the resources for this project are sufficient for the size of the team and scope of work.

Reviewer 2:

The reviewer noted that very good collaboration of the research team with the industry seems to have provided all necessary resources the project needed.

Reviewer 3:

The reviewer stated that the $2 million listed on Slide 2 should be sufficient to complete the entire project.

Reviewer 4:

The reviewer stated that the resources met the objectives.

Presentation Number: EEMS092
Presentation Title: BEAM CORE
Principal Investigator: Anna Spurlock (Lawrence Berkeley National Laboratory)

Presenter

Anna Spurlock, Lawrence Berkeley National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

80% of reviewers felt that the project was relevant to current DOE objectives, 20% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 60% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 40% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

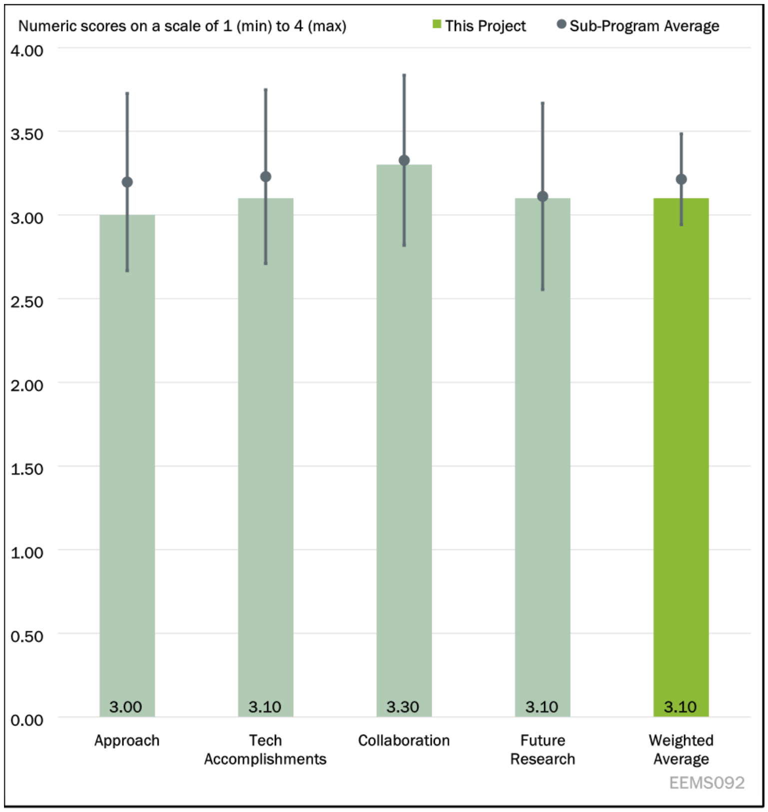

Figure 4-6 - Presentation Number: EEMS092 Presentation Title: BEAM CORE Principal Investigator: Anna Spurlock (Lawrence Berkeley National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer felt the project overall is challenging. There is a large amount of complexity and embedded parameters that make it hard to trace causes and provide transparency. Making the code available may make it transparent but it does not make it or the output practically traceable. As conveyed, there are a lot of exogenously defined inputs that seem to drive the output. This is where these inputs have little uncertainty or variability in the uncertainty which does not appear to be the case.

Reviewer 2:

The reviewer stated that this is a tremendous effort to model a very complex system of systems, with a lot of uncertainty.

Reviewer 3:

The reviewer commented that this is a great project with potentially huge impact. While some barriers are addressed, it is not clear how a couple of remaining barriers mentioned in the slides will be addressed: computational need for processing and knowledge of the existing MPO/ city employees to deploy this software.

Reviewer 4:

The reviewer's predominant concerns with Behavior, Energy, Autonomy, and Mobility Comprehensive Regional Evaluator (BEAM CORE) were centered around longevity/future usage of the tool. The reviewer did not hear the team talking about many technical challenges that need to be addressed (outside of continuing to explore ways to increase the speed of the model). The reviewer heard more challenges related to documentation and transferring the product into the hands of future users of the tool once DOE's funding to develop the tool concludes at the end of the fiscal year. Right now, the tool is being applied for DOE analyses/talking points. The reviewer sought to understand how the tool sustains itself once DOE funding ends in September and who might be targeted to use this tool, such as metropolitan planning organizations (MPO)as part of their analyses. Also unclear was whether users will have access to high-performance computing resources at the national laboratories as well as the staff support to run the models. The reviewer further asked whether MPOs need to come with their own funding for this service. Lastly, with the model applications in Austin and San Francisco presented as part of this AMR, the reviewer inquired what relationship local agencies would have with the BEAM CORE team.

Reviewer 5:

The reviewer commented that the work developing, applying, and running studies with the BEAM CORE platform are focused on barriers around understanding large-scale transportation impacts of new mobility technologies and services. The project team has faced some challenges in addressing these barriers, which has resulted in a timeline that is longer than the results/progress of the development would indicate.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer commented that the technical accomplishments are dependent on the approach which has noted flaws, notably the lack of transparency and dependence on exogenous variables. In Slide 16, the reviewer notes a need to prove the range and median (or distribution), not the income mean. The averages can be biased by some segments, especially on the high end. Slide 20 output for example seems highly dependent on the input and underlying assumptions. Concurrently, it is not clear that there is real-world feedback captured in the model such as limits and balancing effects. The output on Slide 25, specifically the hitch in the "prediction" highlights this weakness. The work is generating output. Greater emphasis needs to be on the insight and fundamentals that lead to those outcomes given the assumptions inherent to the scenarios. It is unclear how to use the output or make the outputs highly actionable or useful at this stage. Sensitivities are not shown and need to be. This is problematic given the levels of dependency and multitude and range of stochastic outcomes. An alternative given the scenario approach is to have a good set of parameter inputs and show the type of outcomes so insights can be generated.

Reviewer 2:

The reviewer stated that the progress on this project is rated outstanding based on task completion and the number of excellent studies that have been completed using BEAM CORE.

Reviewer 3:

The reviewer commented that progress has been great in the past year and the addition of Cruise is great.

Reviewer 4:

The reviewer noted that Slide 11 shows the technical milestones identified for the project. The project appears to be making adequate progress on the identified milestones and on track to complete the project by the September 2023 deadline.

Reviewer 5:

The reviewer stated that the presentation provided a great overview of various components of the BEAM CORE model. One of the stated goals for BEAM CORE development is workflow automation and a reduction in computation time, but no progress towards either (in terms of how many scenario runs can be done, for example) was discussed. The presentation provided many examples of results from several studies, but the causation (e.g., why was there a change in transit ridership, why does fleet adoption change under different scenarios) was not explained.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer noted that the collaboration is sufficiently covered. The problems of connecting and depending on so many other models is addressed in the approach.

Reviewer 2:

That reviewer stated that given all the moving parts, collaboration has to be nearly flawless for everything to work smoothly. Team is commended for managing the complexity.

Reviewer 3:

The reviewer stated that the team is well qualified and has shown a strong collaboration in the past years.

Reviewer 4:

The reviewer felt the collaboration is strong within the national laboratory development community. They do not see evidence that the team is building a community of tool users, which is where they think there is the most opportunity. The reviewer suspects that the most likely future users of this tool are MPOs, but MPOs were not listed as part of the project team to understand the needs/barriers to real world deployment of the tool.

Reviewer 5:

The reviewer commented that the collaboration between national laboratory team members appears tight and highly coordinated. The project may benefit from additional collaboration with on-the-ground stakeholders, as most of the studies highlighted are based on questions from just a few San Francisco Bay area partners.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer noted that creating documentation is necessary. However, the computational complexity and expertise required to use the tool suggests the tool is targeting the wrong audience or is likely to misinform or be misinterpreted by it.

Reviewer 2:

The reviewer stated that the planned future work is appropriate follow-up. It is unclear how much time or resources are required for some of the work.

Reviewer 3:

The reviewer commented that the plan is clear~~.~~ To make this tool impactful the computation need and/ or usability of it needs to be improved.

Reviewer 4:

The reviewer commented that based on the material presented at AMR; the team has a reasonable approach for future work they’ve identified as a team. However, the reviewer did not see how the future research addresses the concerns identified last AMR, which the reviewer thinks are all still highly valid.

Reviewer 5:

The reviewer commented that the proposed future research is planned to focus on increased tool deployment resources and documentation, and on extended stakeholder engagements. While these two foci are important (especially expanded stakeholder outreach), it is not evident that the BEAM CORE platform is in a “final” enough state to switch from tool development to documentation.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer stated that it is not easy to select “no” as there is potential merit. The current weaknesses noted in this review must thoroughly be addressed for the project to meaningfully support program objectives.

Reviewer 2:

The reviewer noted that the project supports the VTO EEMS objective of characterizing transport system energy use and system usage due to the impact of technology and population change.

Reviewer 3:

The reviewer said that this project is very relevant to EEMS.

Reviewer 4:

The reviewer commented that BEAM CORE supports VTO EEMS goals of: (1) develop new tools, techniques, and core capabilities to understand and identify the most important levers to improve the energy productivity of future integrated mobility systems; and, (2) share research insights, and coordinate and collaborate with stakeholders to support energy efficient local and regional transportation systems.

Reviewer 5:

The reviewer stated that the development and application of the BEAM CORE workflow is relevant to overcoming VTO/EEMS program barriers. The insights and findings shown in the presentation are starting to address key questions posed by the project team’s partners and the transportation research community.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented that the funding makes sense given the large team. Unfortunately, this results in an overlay complex and burdensome project that is not efficiently using resources.

Reviewer 2:

The reviewer noted that the project is on track with current level of resources.

Reviewer 3:

The reviewer believed the team has sufficient resources to deliver the project.

Reviewer 4:

The reviewer stated that the resources provided are sufficient for the project to achieve the stated milestones on Slide 11.

Reviewer 5:

The reviewer commented that although the scope and scale of a project to develop a large-scale, open-source comprehensive transportation modeling framework such as BEAM CORE requires significant resources, it is not evident that the current state of development for this modeling platform reflects the significant funding resources that have been provided. It may be beneficial to conduct a full portfolio review to determine if a different resource allocation would be more efficient.

Presentation Number: EEMS093
Presentation Title: Transportation System Impact, POLARIS Workflow Development, Implementation and Deployment
Principal Investigator: Joshua Auld (Argonne National Laboratory)

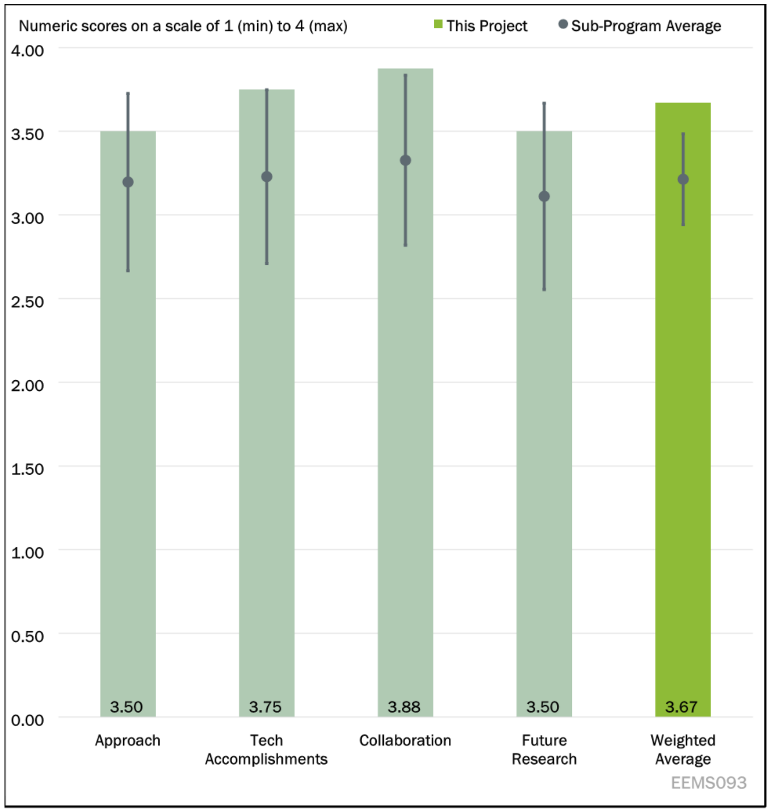

Figure 4-7 - Presentation Number: EEMS093 Presentation Title: Transportation System Impact, POLARIS Workflow Development, Implementation and Deployment Principal Investigator: Joshua Auld (Argonne National Laboratory)

Presenter

Joshua Auld, Argonne National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer noted that the project design does very well at modeling a very complex system of systems, with appropriate integration of data from different system operational scales.

Reviewer 2:

The reviewer commented that while some barriers are addressed, the uncertainty in deployment isn’t fully addressed. Is there a challenge in terms of getting the data needed? How easy/ hard is it for cities to deploy this? What resources/ knowledge the employees would need.

Reviewer 3:

The reviewer stated that based on the material presented at AMR, the project approach seems solid for this stage of the project and the reviewer does not have any concerns about the project team’s approach to addressing the identified technical barriers. The reviewer mentioned really appreciating the efforts that have been made to pull local agencies (North Central Texas Council of Governments [NCTCOG], Atlanta Regional Commission, Chicago Transit Authority [CTA], Chicago Metropolitan Agency for Planning [CMAP], Puget Sound Regional Council, Southern California Association of Governments, Capital Area Metropolitan Planning Organization) onto the project as partners to understand their barriers with using/applying the models and addressing those concerns. The reviewer also really appreciated the conversation about how the best solutions are different for different cities/network structures. The reviewer mentioned thinking this speaks to how transportation solutions are context sensitive solutions, and one size fits all approaches do not work. The reviewer would encourage continued exploration as to what it is about the different cities that enable certain strategies to work better than they do in other cities/land use/network designs. The reviewer suggested connecting with Mona Asudegi of the Federal Highway Administration's (FHWA) Transportation Typology Explorer.

Reviewer 4:

The work developing, automating, and deploying the POLARIS workflow is sharply focused on addressing critical barriers related to understanding and quantifying the potential impacts of future mobility technologies and services on transportation energy and efficiency. The presenter explained the complexities that require application of the model to explore the impact of technologies and policy levers both individually and together, and in different contexts. POLARIS appears well positioned to provide broad capability to assist decision-makers in making technology deployment and policy decisions.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer noted that the scheduled tasks have been completed on time, which is a tremendous accomplishment given the complex modeling tasks. Many excellent studies have been completed, showing the utility of the software tools.

Reviewer 2:

The reviewer stated that the results show great progress. The team has accomplished quite a bit in the past year.

Reviewer 3:

The reviewer commented that the technical progress against the project plan appears to be sufficient. The reviewer does not have any comments about possible barriers to the project reaching completion in September 2023. The reviewer would encourage the project team to continue thinking about what's next for POLARIS in the last two months of the project. If DOE does not supply more funding to the project, has the project team identified future users of the tool? Are appropriate documentation/resources in place for MPOs or other future tool users so that these agencies can pick up and apply the tool without a dedicated DOE funding stream to support application of the model?

Reviewer 4:

The reviewer stated that although the timeline for this project is significant, it is indicative of the significant barriers to large-scale agent-based transportation simulation that robustly incorporates a variety of mobility technologies, modes, and services. The team has made significant progress in automating the POLARIS workflow and engaging with important stakeholders, enabling them to simulate hundreds of future scenarios guided by input from transit agencies, MPOs, and other partners.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer commented that a very large number of inputs is well managed, and needs must be communicated clearly given the system's complexity. An outstanding job by the team.

Reviewer 2:

The reviewer noted that the team has shown good collaboration.

Reviewer 3:

The reviewer really appreciated the efforts that the team has made to pull local agencies (NCTCOG, ARC, CTA, CMAP) onto the project as partners to understand their barriers with using/applying the models and addressing those concerns. The reviewer would think those are the agencies that are most likely to use these tools in the future. The reviewer hopes that their participation has helped increase understanding to the barriers to deploying POLARIS in practice.

Reviewer 4:

The reviewer commented that the POLARIS team has engaged with a large community of stakeholders: other national laboratories and universities for workflow improvement; multiple universities to incorporate new features; and multiple industry, academic, governmental, and trade organizations to conduct studies. The level of collaboration is impressive and is required to successfully complete a project of this scale.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer commented that it was an excellent list of proposed studies and upgrades to software usability and utility.

Reviewer 2:

The reviewer stated that the proposed future research is defined clearly.

Reviewer 3:

The reviewer commented that based on the material presented at AMR, the team has a reasonable approach for future work. The reviewer does not have any concerns with the remaining milestones on Slide 5 or bold future research on Slide 31.

Reviewer 4:

The reviewer noted that a fully featured urban/regional-scale transportation model such as POLARIS may never fully incorporate every possible technology/feature. The project's plan is to continue automating, validating, and deploying the workflow, and conducting studies with stakeholders—all very important. The presentation also shows numerous new features (in terms of EV Charging & Grid, Multimodal, Freight, Behavior, Connectivity, and Land use) that could be added, though it is unclear if all of these will be added. The project team should prioritize which new features will be added in the future.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer commented that POLARIS is a key software system for modeling the impact of VTO technologies on a transportation system. It allows characterization of effects which may be otherwise difficult to measure.

Reviewer 2:

The reviewer stated that the project is very relevant to EEMS. It would be great to see the actual deployment of this tool and see the impact.

Reviewer 3:

The reviewer noted that the project contributes to two VTO EEMS Strategic goals: Strategic goal #1: Develop new tools, techniques, and core capabilities to understand and identify the most important levers to improve the energy productivity of future integrated mobility systems. Strategic goal #3: Share research insights, and coordinate and collaborate with stakeholders to support energy efficient local and regional transportation systems.

Reviewer 4:

The reviewer commented that the development and application of the POLARIS workflow is highly relevant, evidenced by the number of stakeholders that the project team has collaborated with. The insights and findings shown in the presentation have answered key questions posed by federal, state, and local government agencies, transportation agencies, transit agencies, and other stakeholders.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer noted that the work is on track with current budget and people resources.

Reviewer 2:

The reviewer stated that the team has enough resources to carry out the project.

Reviewer 3:

The reviewer commented that the resources appear sufficient for the project to achieve the stated milestones.

Reviewer 4:

The review stated that the POLARIS project team has enjoyed significant funding resources throughout SMART Mobility 1.0 and 2.0. The progress shown in development and deployment of the modeling platform justify the level of funding received. The team has demonstrated good stewardship of their research dollars. While it is likely the project team could accomplish even more with additional funding, a full portfolio review is required to make any necessary changes to resource allocation.

Presentation Number: EEMS094
Presentation Title: Development and Validation of Intelligent CAV Controls for Energy-Efficiency
Principal Investigator: Dominik Karbowski (Argonne National Laboratory)

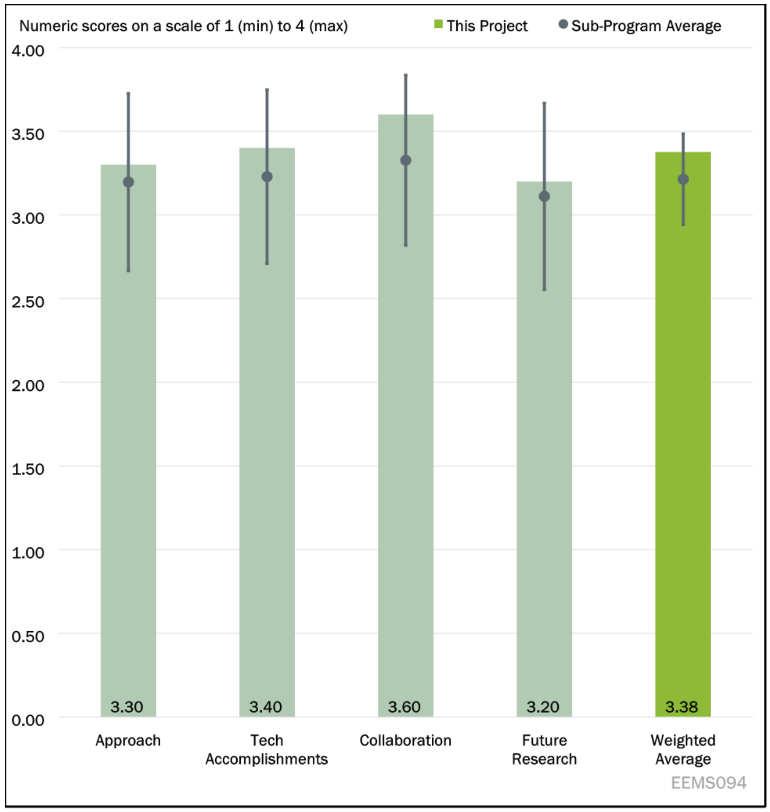

Figure 4-8 - Presentation Number: EEMS094 Presentation Title: Development and Validation of Intelligent CAV Controls for Energy-Efficiency Principal Investigator: Dominik Karbowski (Argonne National Laboratory)

Presenter

Dominik Karbowski, Argonne National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 80% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 20% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer noted that trying to characterize “future” systems is inherently challenging, especially when working in an environment where much info is proprietary. The team does a good job of taking existing resources and adapting them to assess performance in a practical way.

Reviewer 2:

The reviewer commented that Barrier 1 (Slide 2) (CAV development not driven by energy-efficiency) is not addressed well during the presentation. Could address by discussing OEM motivations or how energy-efficiency might piggyback off other benefits that incentivize adoption of these technologies. Barrier 3 (defining representative scenarios) also was not clearly conveyed in the brief— a scenario was defined, though it was not clear how or why it was representative. There is mention of multiple routes; may have been worth elaborating how those were defined and why they were significant. Even with the increasing fidelity of tools (from sim to laboratory XIL to track XIL), the use of a single vehicle with no traffic results in likely overly optimistic energy results. The additional realism introduced by including even simulated micro-traffic may be more valuable than the realism by adding vehicle physics. Great to see overlays (Slide 14) showing how sim results were validated by both laboratory and track XIL. This would allow future work to take place predominantly in sim rather than XIL, thereby saving time and cost. Was the University of Wisconsin testing on public roads? Was there any live traffic? Slide 17 says everything is real, but without any traffic, this isn't quite true.

Reviewer 3:

The reviewer commented that several concerns arise regarding the logical consistency of the findings. For instance, the claim suggesting that having two connected signals in the horizon leads to maximum energy savings appears doubtful. In reality, when signals are positioned within a mile or less of each other, they are typically coordinated and actuated. The coordination ensures that the traffic signal timing fluctuates within certain boundaries. If signals are not properly coordinated, it becomes difficult to assert that the presence of two signals in the horizon results in the highest benefit. Moreover, there is currently no scientific evidence available to substantiate this claim, further casting doubt on its validity.

Reviewer 4:

The reviewer stated that the approach is technically sound, and the project is well defined and designed for execution and the team has demonstrated successfully the technology and results are highly relevant to DOE VTO.

Reviewer 5:

The reviewer noted that the overarching technical barrier is the development of energy saving CAV controls in vehicles that can be measured and then applied to save energy in the fleet. The team's experimental setups—Lab XIL, Track XIL, and Real Track, were well designed and provided a variety of experimental setups that address the complexities of CAVs in multiple scenarios. Their designs have shown results in a variety of experiments. The reviewer appreciated the robustness and considerations in the Full CAV Demo phase of the project. This phase joined the laboratory experiences with real world, real track, situations. The reviewer believes their work is a great foundation for future work and evaluations.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer noted that the team has done an excellent job of executing the tasks defined in the project. The work contributes new techniques that are particularly useful in mixing virtual and real systems.

Reviewer 2:

The reviewer stated that the project is well-planned, and execution has been according to plan. It is a little unclear how planned deliverables may be useful to external stakeholders.

Reviewer 3:

The reviewer commented that the work is progressing according to the established schedule, however, the chosen technical approach for this project raises some concerns. Check my comment in the future work section.

Reviewer 4:

The reviewer stated that the long range V2I results are interesting and come out as expected, but nonetheless an amazing demonstration of technology integration and execution. Testing of the new hybrid electric vehicle (HEV) powertrain in the XIL workflow yielded good results and energy savings. Track XIL proved to be a success from an execution and energy reduction perspective. Interesting to note that real world testing consistently produced better results than XIL. Ran into similar results as well. Tough to explain. The reviewer noted track/virtual demonstration with Clemson was "really neat" and applicable to developing and demonstrating the technology more efficiently than large, closed test track facilities and multiple vehicles.

Reviewer 5:

The reviewer commented that over the past 2 years the team has made significant progress in demonstrating energy efficiency savings with CAVs. The team has achieved and hit all milestones in their work plan.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer commented on an excellent mix of partners, with clear communication needed to execute the various project elements. Well handled by the team.

Reviewer 2:

The reviewer commented that the partners are making substantive contributions to the project. For standardization of energy methods—OEM cooperative research and development agreement (CRADA) is an excellent opportunity. The reviewer was glad to hear during presentation that the OEM partner is willing to be open with results and share with a standards development organization (SDO) and not end up siloed in proprietary ecosystem.

Reviewer 3:

The reviewer said that good coordination is demonstrated.

Reviewer 4:

The reviewer stated that the project pulled in an amazing amount of collaboration from laboratories, universities and OEM(s). This clearly highlights the relevance and potential impact of the project on CAV development and advancing to production.

Reviewer 5:

The reviewer commented that the project team is robust with representation from key industry (GM) and research partners (Clemson, ANL, Michigan Tech). The contributions of GM are particularly helpful in this project by providing driving data and information. Each of the research partners also brought valuable insights and resources to this project. Additional partners may include municipalities or states to gain further insights into real world driving situations and data.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer stated that the next steps are appropriate follow-up.

Reviewer 2:

The reviewer commented that the plan to study CAV controls with traffic flow simulators will hopefully improve realism of the scenarios. Validating models requires closely controlled scenarios and conditions, but afterwards, traffic is required to predict realistic energy savings.

Reviewer 3:

The reviewer noted that while this project’s emphasis on energy efficiency in CAVs is commendable, it is important to recognize that energy efficiency is just one piece of a larger puzzle. Key aspects such as active safety systems, perception algorithms, and machine vision are not included in the project’s scope. These factors are crucial for the overall functionality and acceptance of CAVs. Therefore, while the project will likely make important contributions to energy efficiency, its impact might be limited without addressing these additional factors.

Reviewer 4:

The reviewer commented that the dynamometer XIL for evaluating "powertrain+speed" co-optimization should yield fruitful results. Other research work is on a similar path for CAV on dynamometer, and the reviewer encouraged comparing notes, setup, testing scenarios and results with those efforts. The reviewer is looking forward to this team's outcomes.

Reviewer 5:

The reviewer noted that this project will serve as a good foundation for future work—well done.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer stated that the project is highly relevant to understanding "how" to best control CAVs for optimal energy consumption. Efficient energy use is a key metric for DOE VTO.

Reviewer 2:

The reviewer commented that the project is relevant to VTO EEMS and demonstrates energy savings from connected and automated driving, with simulation results validated by laboratory and track testing.

Reviewer 3:

The reviewer commented that the project is relevant.

Reviewer 4:

The reviewer commented that the program is very supportive and has excellent collaboration with OEM.

Reviewer 5:

The reviewer stated that the project is relevant to the VTO portfolio. The intersection of CAVs and energy efficiency is important and an area that more information and implementation is needed.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer noted that the tasks have been completed on time, with excellent results given the resources available.

Reviewer 2:

The reviewer stated that the resources appear sufficient.

Reviewer 3:

The reviewer commented that while the project's pursuit of energy efficiency in CAVs is indeed noteworthy, my primary concern lies in the limitations of the technical approach adopted. The project does not seem to address integral aspects such as active safety systems, perception algorithms, and machine vision. These components are essential to ensure not only the efficiency but also the safety and reliability of CAVs. Original Equipment Manufacturers (OEMs) might find it challenging to implement the tools and methodologies proposed by this project, considering these safety aspects are not included in the project's scope. Based on this, the reviewer believes there is high risk in allocating funds researching this area.

Reviewer 4:

The reviewer noted that the team has every resource needed and support from OEMs and excellent collaboration with universities with distributed resources for execution of various aspects of the project.

Reviewer 5:

The reviewer believed the budget is sufficient for the research.

Presentation Number: EEMS095
Presentation Title: Integrated Control of Vehicle Speeds and Traffic Signals for Reducing Congestion and Energy Use
Principal Investigator: Jinghui Yuan (Oak Ridge National Laboratory)

Presenter

Jinghui Yuan, Oak Ridge National Laboratory

Reviewer Sample Size

A total of six reviewers evaluated this project.

Project Relevance and Resources

83% of reviewers felt that the project was relevant to current DOE objectives, 17% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

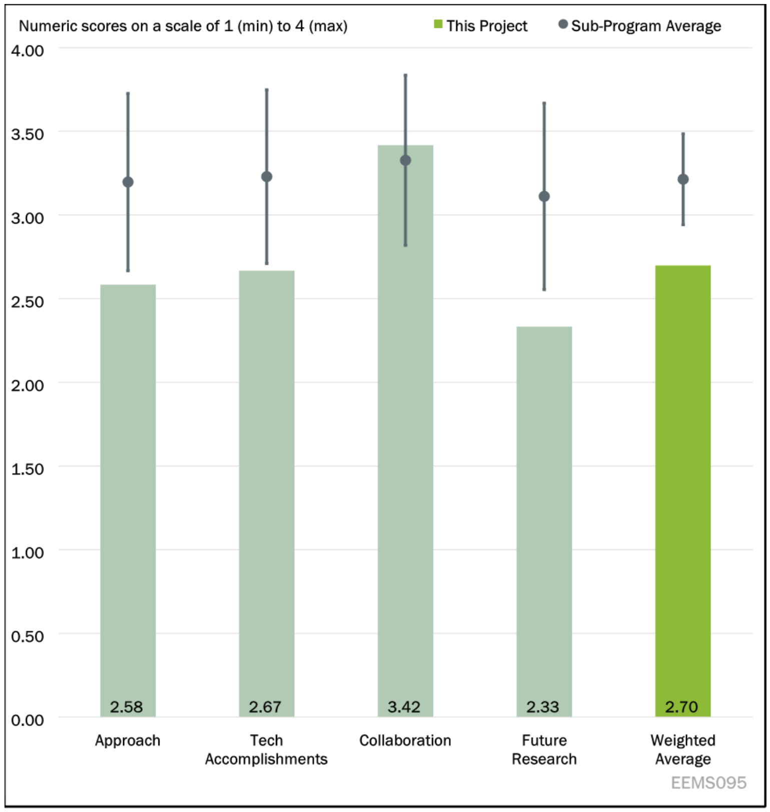

Figure 4-9 - Presentation Number: EEMS095 Presentation Title: Integrated Control of Vehicle Speeds and Traffic Signals for Reducing Congestion and Energy Use Principal Investigator: Jinghui Yuan (Oak Ridge National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer noted that the Connected and Automated Vehicle Environment (CAVE) dynamometer work is delayed. It is unclear if this work will be completed before the project end, and if there will be enough correlation and fidelity in the system to provide meaningful results. In addition, the % efficiency gains need to be allocated between signal control and connected vehicle changes, since both can be implemented exclusively.

Reviewer 2:

The reviewer referenced the use of simulation, dynamometer, and on-road testing. The reviewer also noted the use of Gridsmart (minute-by-minute) and National Transportation Communications for Intelligent Transportation System Protocol (NTCIP) controller data to connect to the cloud and use of cellular for messaging. The reviewer also noted the use of global navigation satellite system (GNSS) in vehicle for localization and the use of Vissim software for simulation and mentioned aggregating minute-by-minute traffic data by 5-minute averages may miss much of the important traffic dynamics. Finally, the reviewer emphasized the inclusion of microscopic traffic modeling and vehicle sensor data for signal control, with change splits only.

Reviewer 3:

The reviewer stated that it is reasonable to start with theory before proceeding to real-world. However, given the objective is to solve real-world conditions not incorporating low-hanging fruit into the modeling to capture the most relevant types of real-world factors that undermine theoretical ideal case is a flawed approach. The work plan does not appear to offer differentiated value add over a suite of other similar and related work.

Reviewer 4:

The reviewer commented that the study has identified and addressed many of the complexities in using communications to reduce energy consumption in the interaction between vehicle speed and traffic signal timing. The study demonstrates the benefits of vehicle connectivity even when the CAV penetration rate is low. The remaining barriers and challenges identified note that human interactions with drivers are not examined; to this the reviewer recommends adding pedestrian interaction, which often substantially increases the cycle length for traffic signals, sometimes substantially reducing highway traffic signal efficiency.

Reviewer 5:

The reviewer stated that the partnership with Toyota is excellent, but this is one of many OEMs that will need to adopt and adapt their vehicles to be able to implement and validate something like this at a larger scale. Having other industry groups involved would give a better understanding and representation of what is feasible in order for the proposed approach to work.

Reviewer 6:

The reviewer observed that the degree to which technical barriers were addressed was satisfactory. The reviewer is very curious as to why a phone app was chosen rather than a cellular-vehicle-to-everything (C-V2X) solution with the SAE standard, which includes security protocols.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer noted that the technical progress is satisfactory but appears to be behind compared to the original project plan.

Reviewer 2:

The reviewer noted that the project team has seen 9% energy savings from signal control algorithm alone (compared to semi-actuated). Integrated with vehicle control gets up to 27% efficiency for a vehicle, nearly 25% for system improvement with 100% CAV. At 20% CAV, closer to 7% system improvement. Had a delay in CAVE laboratory but are back on track and testing traffic signal controls end of this month and then in early August on-road testing.

Reviewer 3:

The reviewer commented that the work is largely disconnected from the real-world and factors that lead to difficulty in optimization. The five-minute average speed is problematic, and the researchers did not have an adequate response. The model does not appear to incorporate many relevant factors such as people, bikes, and their variability on how or when a vehicle can proceed. The major barriers and remaining challenges noted by the research team are problematic and unless overcome will preclude achieving the objective. Results so far have no practical use and may not unless the barriers are overcome. It was not sufficiently made clear how this will be accomplished.

Reviewer 4:

The reviewer stated that the efforts to develop algorithms ready for field testing in a Toyota test vehicle with communications to the Chattanooga traffic signals demonstrate progress toward field implementation and evaluation.

Reviewer 5:

The reviewer noted that based on the timeline, this project is close to completion. However, the barriers that are left to accomplish still seem significant. Will the rest of the project objectives (ending Dec 2023) be able to successfully be accomplished without an extension? This is a very complex project and topic, potentially showcasing the results as a proof proof-of-concept might be appropriate given the objectives are currently stated more globally and this does not include a mixed fleet set of results just one type of vehicle.

Reviewer 6:

The reviewer wrote: Good. The project outlined what it was going to do, and then set accomplishments to that goal. Although, the reviewer does wonder, “So what?”, the reviewer was optimistic that there was 100% CAV penetration rate versus something perhaps as to what the market would actually be during a forecasted timeframe. Also, again there is a C-V2X protocol, which also includes the Road Side Unit Protocol, and the reviewer was wondering why that was not chosen either. The reviewer commented that this also could have been optimized, if there had been a focus on “latency” with needed cell phone towers, and finally asks which GNSS was chosen (e.g., GNSS L1, or other?).

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer stated that the collaboration appears to be well coordinated. It is welcome to see the regular interactions with Toyota.

Reviewer 2:

The reviewer commented that the project team is working with Toyota on algorithm, vehicle testing, and integration. Collaboration and leveraging other DOE work and collaborators.

Reviewer 3:

The reviewer commented that the collaboration is effective in achieving the intended support.

Reviewer 4:

The reviewer stated that the full involvement of both vehicle and highway traffic signal stakeholders was demonstrated and is exemplary.

Reviewer 5:

The reviewer stated that the topic has a lot of implications for OEMs, Toyota is included, and it is a great starting point. However, having more representation of industry in the concept and validation process would be beneficial. Investing resources of this magnitude might call for a stakeholder’s group or some type of peer review before the end of the project.

Reviewer 6:

The reviewer observed excellent collaboration within the project team, as a city and an OEM were included. The reviewer commented that they would have taken this further as written, but including an LTE provider, cell phone towers, (4G, 5G?), noting GNSS and noting even the cloud provider. The reviewer expressed less enthusiasm about using a phone app.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer commented that since on-road work and field evaluation is yet to be started, it will be difficult to complete this work by the end of the project. There will likely be continual integration work and correlation work between the road, laboratory and simulation which will extend the expected testing period.

Reviewer 2:

The reviewer stated that there are clearly defined next steps for project work. No detail was provided on potential "icing on cake" future work or additional applications.

Reviewer 3:

The reviewer noted that the proposed future research does not sufficiently make clear how barriers and challenges will be overcome to achieve useful or practical real-world application as stated in the objective.

Reviewer 4:

The reviewer stated that the lack of a specific control for interactions with other road users is concerning. These interactions may be with other drivers, pedestrians, commercial vehicles, and buses. These interactions may be lurking in the results of the field evaluations; understanding them may be important.

Reviewer 5:

The reviewer commented that it is not clear that the future work and the barriers that still need to be overcome will prove fully transferable to other vehicle models. The suggested leveraging of other projects Virtual and Physical Proving Ground (VPPG) for Development and "Validation of Future Mobility Technologies" (EEMS067) and "Scaling up the Realtime Data, Simulation and Artificial Intelligence (AI) and Control for Optimizing Regional Mobility" (EEMS061) seem like a great way to ensure this project can accomplish the remaining work by December 2023.

Reviewer 6:

The reviewer commented that they think the project team needs to look at what other technologies are out there, to do something similar, and drill down on the "communication aspects" as well as the "real world" penetration of CAVs.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer stated that this project solidly supports EEMS objectives.

Reviewer 2:

The reviewer commented yes, aiming for energy efficiency improvement through CAV/CDA system. Includes real-world demonstration and validation.

Reviewer 3:

The reviewer stated that as explained, the concept has merit, but there is not a clear pathway to achieve the goals—in supporting vehicle and system efficiency.

Reviewer 4:

The reviewer noted that subject to limits from the interactions with other road users, the work demonstrates that CAVs may be able to reduce the transportation energy consumption associated with the interactions of vehicles and traffic signals.

Reviewer 5:

The reviewer stated that the topics covered in this project are very important and relevant to VTO. This project assists and expands on the need to be able to use real-world data for validation purposes. Using it to optimize models and other unique types of vehicles (e.g., commercial vehicles) is something that VTO could expand and use in future projects.

Reviewer 6:

The reviewer noted that they would just approach this differently, technically, based on where the OEMs are going, and also based on SAE standards in this space.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that the resources appear to be sufficient. Readiness of the CAVE laboratory should be accounted for in future work/projects.

Reviewer 2:

The reviewer noted that the project team has appropriate equipment for simulation, dynamometer, and deployment testing with real vehicles.

Reviewer 3:

The reviewer stated that the resources are appropriate.

Reviewer 4:

The reviewer commented that the project team demonstrated progress in developing and evaluating algorithms, working with Chattanooga on signal communications, and working with Toyota on vehicle implementation, including dynamometer testing and developing field testing. This indicates that resources are sufficient for the project. Additional funds might be used to analyze user interactions and widen field testing if the initial tests prove successful.

Reviewer 5:

The reviewer stated that it seems that the current funds should be sufficient to complete the remaining tasks by December 2023.

Reviewer 6:

The reviewer commented that the resources are just okay.

Presentation Number: EEMS096 Presentation Title: Characterizing Behaviors and Capabilities for Emerging Connected and Automated Vehicle Technologies and Sensors Principal Investigator: Thomas Wallner (Argonne National Laboratory)

Presenter

Thomas Wallner, Argonne National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 80% of reviewers felt that the resources were sufficient, 20% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

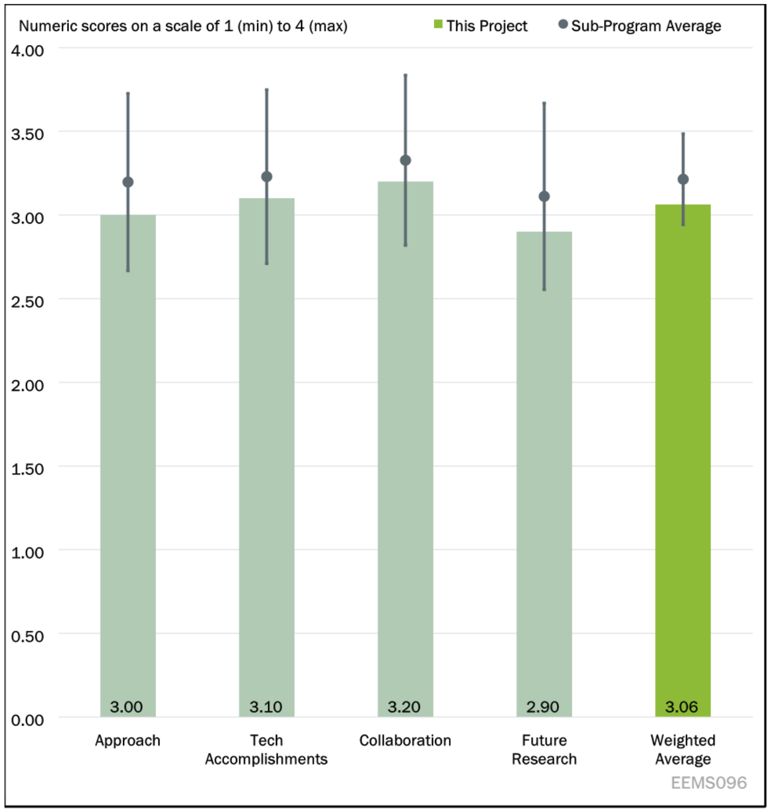

Figure 4-10 - Presentation Number: EEMS096 Presentation Title: Characterizing Behaviors and Capabilities for Emerging Connected and Automated Vehicle Technologies and Sensors Principal Investigator: Thomas Wallner (Argonne National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer commented that the project and its data collection, though challenging, seems to have been approached thoughtfully. It is also 80% complete. Attention has also been given to addressing review comments in a proactive way—for example, previously a reviewer commented that the team should strengthen their SAE standards participation and since that time the PI was appointed to chair a related task force.

Reviewer 2:

The reviewer felt the project was well designed to address advanced driver assistance system (ADAS) data collection barrier described.

Reviewer 3:

The reviewer stated that the project seems to be focused on the data collection from sensors in production vehicles, but at the same time the group is adding further off-the-shelf sensors to the production vehicles. The reviewer finds this slightly confusing as it conflates the situation on the true data collection capability of a given vehicle. Furthermore, the researchers mention that the software algorithm significantly affects the quality of the data for real-world use, but they then aim to separate the algorithm from the sensor performance. This seems like a huge gap in the approach, and the reviewer wonders about the utility of the final results in evaluating the capabilities of current production CAVs. The pace of sensor development is also quite fast, so the relevance of the collected data for future systems might also be called into question.

Reviewer 4:

The reviewer commented that the "Traffic interferes with advisory," (Slide 8) presentation, mentions use of a green light speed advisory (GLOSA) coast request. While this may be feasible for an individual vehicle request, the reviewer asks whether it is viable if multiple vehicles are requesting. To be operationally viable, how would the infrastructure adjudicate many requests? Would they need to be coordinated across multiple intersections as well? For the Tesla Full Self Driving (FSD) data set, is the objective to improve FSD using the additional instrumentation and algorithms (Slide 10)? Or is the new capability confined to only assessing CAV performance? For the medium-duty (MD) and heavy-duty (HD) data collection, was the vehicle obviously a CAV? Curious if that would change human driver behavior. Also, were the platooning algorithms developed by the private sector? If so, were they different across the two companies (Locomation and Cummins)? CAV sensor data collection in snow and rain helps fill the technology gap and the demonstrated benefit is from incorporating road weather data. Also, a good independent verification of sensor manufacturer performance claims. Excellent presentation with clear identification of major takeaways.

Reviewer 5:

The reviewer suggested that the project could add clarity to its data collection. The reviewer thinks the data itself needs to be clearly noted as to what is collected, why it is collected, and how it ties into an overall framework of data required for analysis.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer stated that in spite of COVID, prior to this year it appears that they continued to make progress on their project. Moreover, since the last AMR many milestones have been completed and, though September is quickly approaching, it seems strong progress was made over the past year towards advancing and working towards wrapping up the work.

Reviewer 2:

The reviewer commented that the team has done very well in acquiring data from vehicle systems under the constraint that no invasive modifications could be made. The adaptations required to get the relevant data are well executed.

Reviewer 3:

The reviewer commented that the amount of data collected in this project is okay, but it really is quite modest relative to the huge amounts of data being collected by OEMs. So, it is a valid question whether the accomplishments are enough and really meaningful in influencing the trajectory of the R&D for CAVs.

Reviewer 4:

The reviewer noted that the project execution has been timely, and deliverables are relevant to external stakeholders.

Reviewer 5:

The reviewer considered this overall project as satisfactory, but noted that some of the same issues raised in the 2022 AMR presented here as this project continued.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer commented that the project has engaged and dedicated different tasks to a diverse range of collaborating partners representing industry, national laboratories, and other external entities. Discussions also appear to be underway with an additional partner (Plus AI), which could add another dimension. It is good to see they have connected with SAE as well.

Reviewer 2:

The reviewer noted that there was a good mix of collaborators from industry, government, and standards orgs. Would be improved with greater vehicle OEM participation but it is understandable that this is difficult given the proprietary nature of much of the systems being assessed.

Reviewer 3:

The reviewer stated that this project would clearly benefit from greater collaboration and coordination with OEMs to enhance data collection.

Reviewer 4:

The reviewer commented that the partnerships with other national laboratories and industry appear strong and relevant. It is helpful to have multiple partnerships in case companies (e.g., Locomation) drop out. What is the nature of the partnership with Waymo for sensor characterization? Are they just providing data? Are they also planning to test with the new characterization to determine benefit? Between the industry partnerships and ANL staff's newly appointed role on SAE committee, this project now has immediate and direct relevance to industry.

Reviewer 5:

The reviewer stated that the project team notably was working on reaching out and doing more collaboration, but the review did not discern from the project a clear overall strategy for collecting data.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer commented that not only did the project lay out a number of opportunities for future work (such as developing and testing weather-specific sensor degradation error models) but they have also appeared to have taken steps to further explore/advance these efforts. For example, they mentioned that they are proposing to develop a traffic-aware GLOSA and are now in talks with Traffic Technology Services to build such a system.

Reviewer 2:

The reviewer commented noted there are an excellent set of follow-up tasks, possibly hampered by limited data sources.

Reviewer 3:

The reviewer commented that again, the evaluation of data quality in absence of algorithm seems a little off target. The effect of the algorithm is huge. Raw data may be significantly enhanced.

Reviewer 4:

The reviewer stated that please see comment above about traffic-aware GLOSA—a single vehicle demonstration would be valuable but not representative of reality. It may be more valuable to mature with multiple vehicles in pure simulation (which could lead to a simpler but realistically technically viable product) rather than do a physical demonstration with just one vehicle (great research but potentially a point source rather than systemic solution). “Sensor agent data standards”—The presentation described this as an “integrated way of reviewing sensor performance and processing to provide more realistic assumptions so others can use in their modeling efforts.” There may be overlapping equities here with multiple DOT efforts and is an opportunity for future collaboration.

Reviewer 5:

The reviewer scored the project as “satisfactory” but strongly felt the team should recalibrate what they are trying to do with “collecting data.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer noted that the EEMS Program conducts early-stage R&D at the vehicle, traveler, and system levels, creating new knowledge, tools, insights, and technology solutions that increase mobility energy productivity for individuals and businesses. CAV technology presents potential to impact transportation energy consumption and emissions. This project aims to fill gaps in performance data regarding CAV technologies which could be valuable potentially, looking forward.

Reviewer 2:

The reviewer stated that how an ADAS-equipped vehicle “sees” the world is critical information in understanding how to model and assess ADAS effectiveness. The technology is one of the key levers for improving overall transport energy system efficiency, which is a key DOE VTO goal.

Reviewer 3:

The reviewer commented that the scope of this project is too small. Greater amounts of data and evaluation of algorithms under normal and adverse conditions would benefit this project.

Reviewer 4:

The reviewer stated that the project is relevant to VTO EEMS program. The ADAS data collection can help inform existing questions about traffic impacts, and the HD truck data from Cummins and Locomation are excellent collaborations with industry.

Reviewer 5:

The reviewer believes the project needs a better strategy as to what this project is really trying to do, and why.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that there are a few milestones remaining but if things continue on schedule, funding is likely sufficient based on current plans.

Reviewer 2:

The reviewer noted that the scheduled tasks are on track with the resources available.

Reviewer 3:

The reviewer commented that the scope of this project is too small. Greater amounts of data (through a larger scope or collaborations with industry), and evaluation of algorithms (in addition to data) under normal and adverse conditions would significantly benefit this project.

Reviewer 4:

The reviewer stated that the resources appear sufficient.

Presentation Number: EEMS097
Presentation Title: Micromobility-Integrated Transit and Infrastructure for Efficiency (MITIE)
Principal Investigator: Andrew Duvall (National Renewable Energy Lab)

Presenter

Andrew Duvall, National Renewable Energy Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

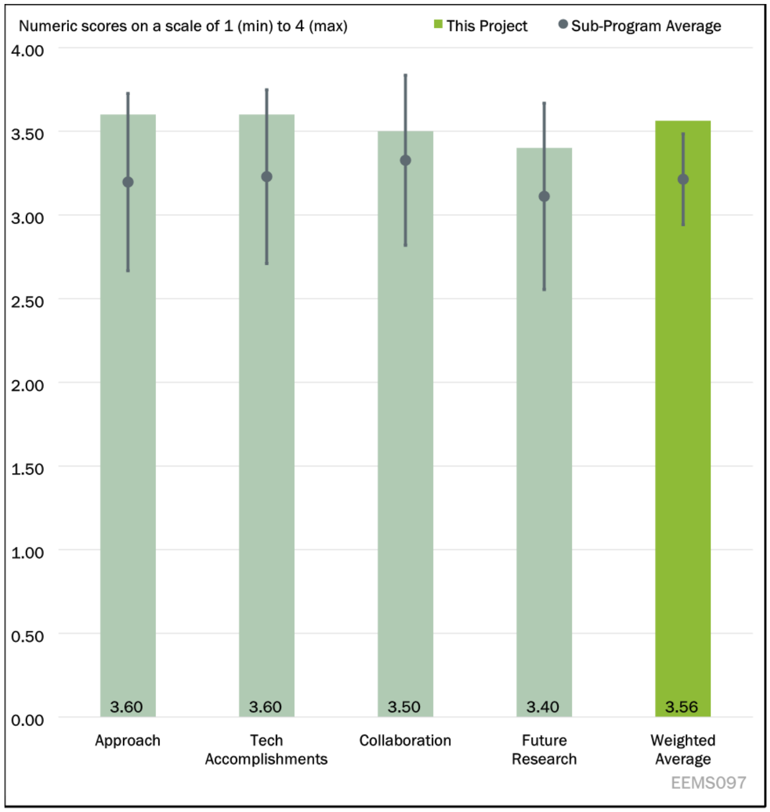

Figure 4-11 - Presentation Number: EEMS097 Presentation Title: Micromobility-Integrated Transit and Infrastructure for Efficiency (MITIE) Principal Investigator: Andrew Duvall (National Renewable Energy Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer commented that the project approach is appropriately broad to address the objectives of a comprehensive set of micromobility scenarios to be integrated into workflows including micromobility and microfreight operations. The approach includes energy estimates of micromobility for workflow scenarios, multimodal connection with transit, mode choice, induced demand, and infrastructure, energy optimization of micromobility operations, and microfreight.

Reviewer 2:

The reviewer noted that the researchers are conducting research in an area that has not been extensively studied in the past. So, the research is addressing an area where information is still limited, and as such represents a barrier. The research is reasonably well designed, and the researchers have made good progress in reaching the project objectives.

Reviewer 3:

The reviewer stated that the study undertook to address important questions regarding the potential energy savings from micromobility devices. The research approach and resulting evaluation contributed importantly to our knowledge of micromobility in the context of roadway users’ travel decisions.

Reviewer 4:

The reviewer commented that this work is excellent because it analyzes micromobility in the context of the mobility energy production (MEP) metric and is making progress in developing and analyzing data about micromobility.

Reviewer 5:

The reviewer commented that over the course of this project the team has addressed the challenges of understanding the intersections and integration of e-mobility systems into the larger transportation system. The team has partnered with a variety of partners including research institutions, varying levels of government, and providers to test real world usage and application of micromobility into transportation systems. Their research and techniques will help to gain more understanding of how micromobility is reshaping transportation and transportation options.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer stated that the technical accomplishments noted were MEP analysis of e-bike mode and energy estimation of dockless micromobility. E-bike program data showed that more than 34% of trips replace single occupancy car trips and can provide as much as 80% of the quality of mobility of a much faster mode such as driving. Dockless micromobility energy and trip attribute data yield insights on system performance.

Reviewer 2:

The reviewer commented that the researchers have conducted modeling runs and have estimates on micromobility efficiencies. They are coordinating with the MEP team, which is now incorporating micromobility into its toolset. The researchers are now disseminating the results.

Reviewer 3:

The reviewer noted that the study importantly contributed to our understanding of energy use of micromobility devices vis-a-vis other travel modes. Using recently developed MEP measures, the study demonstrated that the quality of the mobility provided by micromobility devices can sometimes approach that of automobiles.

Reviewer 4:

The reviewer commented that the technical progress is excellent since they have already produced meaningful insights and are on schedule with respect to their project plan.

Reviewer 5:

The reviewer stated that the team has made remarkable progress on this project. This includes integration of this data into MEP as well as multiple manuscripts being produced by this work. The reviewer concluded, “Well done.”

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer noted good collaboration among NREL as a lead and LBNL, PNNL, and ANL as project partners. Complimentary research is being carried out by EPA and several universities. Numerous industry stakeholders have participated to inform the project approach, share their micromobility use data and relevant program insights.

Reviewer 2:

The reviewer observed the team incorporates a good group of researchers from national laboratories, non-lab/academic partners, cities, and associated industry partners. This is critical, as information in this area is still sparse, and the connection with cities can be important in incorporating micromobility into city planning.

Reviewer 3:

The reviewer noted that the study demonstrated wide consultation. A clearer explanation of how the consultation influenced the study might be helpful.

Reviewer 4:

The reviewer commented that collaboration and coordination across the project team is excellent because they have collaborated with a set of interested organizations for data collection and are leveraging the EEMS expertise on MEP to enhance their team's effectiveness and productivity.

Reviewer 5:

The reviewer felt the partnerships on this project are outstanding. The team has governmental, non-governmental and industry partners participating on this project. The collaborations in this project have helped the team obtain key user data as well as data in cities across the U.S. The reviewer mentioned also appreciating that the partners, especially city partners, are varied and from multiple geographic and sociodemographic areas.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer noted that the proposed future research covers the 3rd and last year of the project (FY 2023). Remaining milestones in FY 2023 are appropriate and include final project documentation, presentation and publications.

Reviewer 2:

The reviewer commented that this research is near completion, so the future work is primarily dissemination related. The researchers appear to be staying connected with partners and stakeholders, which will provide for opportunities to put this research into practice, and it appears that the researchers are actively looking for additional funding in the area.

Reviewer 3:

The reviewer noted that the current phase of the work is wrapping up. One unaddressed issue that the study noted was the lack of use data; is there a technical way to address this that might be the subject of future research? How does the service model for shared devices impact energy savings?

Reviewer 4:

The reviewer commented that the near-term future work makes sense since they have useful results and getting those results disseminated and socialized will maximize DOE's return on investment. The longer term future work makes sense since the project has shown that micro mobility offers energy efficiency advantages, and the development of practical enabling strategies is a logical next step.

Reviewer 5:

The reviewer stated that the project has clearly outlined future work and research opportunities.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer stated that the MITIE project supports the EEMS subprogram objectives by advancing technologies and systems to improve MEP when adopted at scale and exploring modes that have not been well studied in the context of energy impacts.

Reviewer 2:

The reviewer commented that the area of micromobility is going to be an importance piece of developing an overall strategy for improving mobility options going into the future. Micromobility will also be important in developing strategies around first and last mile solutions for bus and rail transport users. This project should provide some important information on filling the gaps on micromobility. This research could also help to guide in planning at a more local/city level.

Reviewer 3:

The reviewer noted that the study demonstrated the potential energy savings from micromobility devices.

Reviewer 4:

The reviewer stated that the project supports the EEMS Program objectives by analyzing micromobility transportation using the MEP metric.

Reviewer 5:

The reviewer stated that this project is key to VTO objectives. Mode shift and micromobility are a growing component of the transportation landscape and understanding the infrastructure, energy needs and energy efficiency benefits are essential to the overarching work of eliminating emissions in the transportation sector.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented that DOE is funding 100% of the project with a total of $2.68 million. Given the broad scope, partners, and barriers (uncertainty of future mobility systems and evaluating MEP at scale) the overall project budget seems appropriate.

Reviewer 2:

The reviewer noted that the project is near completion, and it appears that there were sufficient resources to accomplish the current scope of work. It will be interesting what resources might be available through future funding opportunities.

Reviewer 3:

The reviewer stated that the study seems to have progressed with available resources, with meaningful results demonstrated.

Reviewer 4:

The reviewer commented that the project has been productive with the resources provided.

Reviewer 5:

The reviewer commented that the resources are sufficient for achieving the milestones in the project.

Presentation Number: EEMS098
Presentation Title: Optimizing Drone Deployment for More Effective Movement of Goods
Principal Investigator: Victor Walker (Idaho National Laboratory)

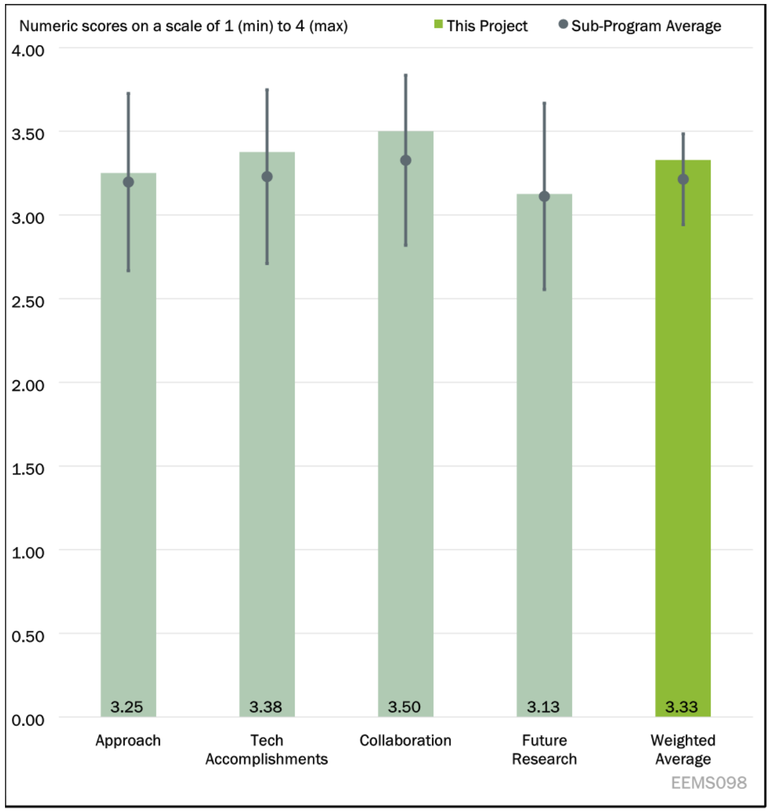

Figure 4-12 - Presentation Number: EEMS098 Presentation Title: Optimizing Drone Deployment for More Effective Movement of Goods Principal Investigator: Victor Walker (Idaho National Laboratory)

Presenter

Victor Walker, Idaho National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer commented that the team's approach of combining, open environment testing, laboratory-based testing, simulation & optimization, and validation to study the energy impacts and performance of drone-based delivery of goods, is a sound one.

Reviewer 2:

The reviewer noted that the project identified a number of barriers but could do a better job of explaining how the specific project research addresses them. For example, looking at routing options and weather impacts has some impact on sound and safety and "secrecy," but those are only obliquely touched on, and it is not clear how this project addresses standards. The project would be stronger if it connected the dots more clearly.

Reviewer 3:

The reviewer stated that the results of the project in addressing the barriers are good in that they have provided insights into the energy use and performance of drone delivery systems. The results are also good in illuminating risk factors associated with each drone delivery mode.

Reviewer 4:

The reviewer commented that the project has maintained a solid progressive research approach for a five year timeframe for better understanding the energy impacts and performance attributes of drone technology and to accelerate drone technology development for select delivery applications. The research progressed from laboratory-based testing in controlled environments, to open environment testing to gain insights on flight operations and climatic affects, to simulation and optimization of operations, to scaled testing and validation of deployment scenarios, and finally industry tool development to assist in planning and assessment. The five year timescale seems appropriate and well planned for the tiered research approach.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer noted that the accomplishments on the project include: 1. Extensive tests to validate drone models; 2. Study of drone/electric vertical takeoff and landing (eVTOL) type and number to complete 58 deliveries with a per delivery time window of 20 minutes. Quantification of kilowatt-hour and delivery minutes; and 3. Study of mixed vehicle fleets (Hyundai Accent + drone/eVTOL) to deliver to more distant destinations.

Reviewer 2:

The reviewer commented great data on weather, delivery times, etc.

Reviewer 3:

The reviewer commented that the analysis domain of this project has a lot of variables which makes the analysis challenging. The project team has made good technical progress in the sense that they are producing some practical insights even while they wrestle with the complexities.

Reviewer 4:

The reviewer stated that the project appears to be slightly ahead of schedule given the stated 75% completion and anticipated project end date of October 2025. Several insights were gained from the research in the reporting period. The research continued new validation testing on rotary drones to support model optimization. The research investigated weather impacts on different drone type operations. Through direct-to-consumer delivery testing, the team determined small batteries reduce energy needs but also reduce range and increase battery mgt needs; and drone integration with ground vehicles may be needed to meet all delivery requirements due to drone range and weather limitations. The team also made progress on tool/energy calculator development.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer stated that the collaboration with primary and supporting industry and academic partners is quite impressive. Also, this is a partnership between INL and ANL.

Reviewer 2:

The reviewer commented that this was a good team, but they would still love to see more private sector partners, particularly end users of the delivery technologies.

Reviewer 3:

The reviewer noted that the collaboration with industry appears to be excellent as they are able to focus on real-world scenarios.

Reviewer 4:

Collaboration on this project is terrific. The researcher team is working with a variety of collaborators including other national laboratories (INL and ANL), industry, manufacturers, service providers, and academia

(The University of Texas at San Antonio and Carnegie Mellon). The collaboration provides comprehensive stakeholder coverage of drone research in the context of real-world delivery operations.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer stated that the future work plan which includes tool development, testing, working with regulations and needs, etc., is well-motivated and sound.

Reviewer 2:

The reviewer noted that they would like to see more discussion/explanation of future applications and research directions. For example, it sounds like these tools could be used to develop an application programming interface (API) to allow optimized technology selection and dispatching based on various factors, but that was not entirely clear or explained.

Reviewer 3:

The reviewer commented that the focus on working with industry for future research is excellent since it will influence the work to focus on practical issues and scenarios.

Reviewer 4:

The reviewer stated that the future research is clearly defined and builds nicely off the previous work under the project. The remaining research involves completing the energy use and operational impacts analysis of the mixed fleet scenarios and software tool development for supporting industry drone decision-making and operations planning.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer stated that this project studies the energy impact and performance of drone-based delivery of goods. This approach could lead to more efficient transportation of goods and thus reduce CO_2. This aligns with VTO program objectives.

Reviewer 2:

The reviewer noted that the project helps clarify when, whether, and how drone technology can contribute to EEMS.

Reviewer 3:

The reviewer stated that this work is highly relevant to understanding the energy efficiency of emerging mobility solutions.

Reviewer 4:

The reviewer noted that this project is very relevant for the EEMS program area. The project supports research on drones for supporting a variety of practical delivery applications and their positive energy use implications.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that the allocated resources of $1.85 million over 5 years for this project are adequate.

Reviewer 2:

The reviewer said that there is nothing further to add here.

Reviewer 3:

The reviewer stated that the project team is being productive with the resources that they have been allocated.

Reviewer 4:

The reviewer noted that the PI indicated the project is scheduled to be completed by October 2025. The PI stated that the project research is about 75% complete. The total resources available for the project appear sufficient for completing the remaining work.

Presentation Number: EEMS099
Presentation Title: Metrics for Assessing the Impacts of Energy-Efficient Mobility Systems (EEMS)
Principal Investigator: Venu Garikapati (National Renewable Energy Laboratory)

Presenter

Venu Garikapati, National Renewable Energy Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 67% of reviewers felt that the resources were sufficient, 33% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

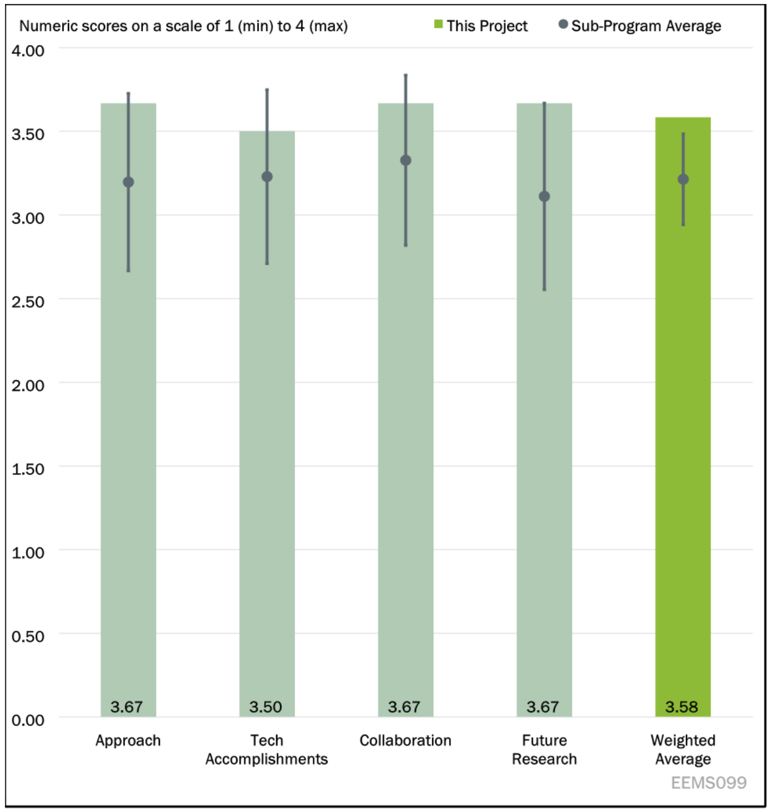

Figure 4-13 - Presentation Number: EEMS099 Presentation Title: Metrics for Assessing the Impacts of Energy-Efficient Mobility Systems (EEMS) Principal Investigator: Venu Garikapati (National Renewable Energy Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer commented that understanding the impacts of different mobility options can be an important barrier to overcome in developing comprehensive strategies for transportation. The authors have used a reasonable approach in enhancing the development of their MEP calculations and are on track to complete the technical tasks as planned.

Reviewer 2:

The reviewer stated that the approach to addressing the barriers is outstanding since it is effectively developing and enabling deployment of practical and cohesive metrics to evaluate new mobility technologies.

Reviewer 3:

The reviewer commented that the PI has excellent understanding of the topic, and the three year period seems to be a reasonable timeline. The reviewer is a bit worried about the percentage complete (80%), as there is only about 3 months till the end of project.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer stated that this project is nearly completed, and it appears that most of the technical tasks have been completed or are on track for completion. The remaining milestones for the third year appear to be focused on summarizing the results and disseminating the results, which is in progress.

Reviewer 2:

The reviewer commented that the technical accomplishments are effective as evidenced by deployment within and outside DOE.

Reviewer 3:

The reviewer stated that based on the milestones listed in the presentation, it seems that everything is on track.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer commented that the team has good coordination and cross collaboration, a strong team of national laboratories, as well as departments of transportation and industry partners. The number of cities that the researchers are collaborating with or in discussions for collaboration is impressive. It is also useful that the researchers are looking for ways to broaden access/lower the threshold for adoption for the MEP model, including the multi-tier approach to coordinating with collaborators.

Reviewer 2:

The reviewer noted that this project appears to have an impressive set of collaborations ongoing.

Reviewer 3:

The reviewer highlighted the lack of partnership of industry and continued that this topic might be a bit less relevant to industry but more public agency. Maybe the research team could consider some consulting companies if they count.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer commented that this research is near completion, and the authors are on target with their investigations. The future research plans for path-based MEP calculations, developing MEP scorecards for different cities, and using OpenStreetMap within the application seem to be useful augmentations to the work.

Reviewer 2:

The reviewer noted that the future work appears to focus on increasing the availability of tools and data that everyone can use to apply the metrics to evaluate real-world transportation applications which is excellent because it will allow the work to be used for practical benefit. It also has potential to provide insights to researchers that will improve their metrics.

Reviewer 3:

The reviewer commented that the proposed future research is clear. A standardized procedure would be much more effective to propagate the research results. It would be great if weather information can be integrated into the calculations of MEP.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer stated that overall, it appears the MEP is a leading model that is being adopted more widely. With DOE funding, the MEP model appears to have been extended and broadened in its usefulness. Overall, this project appears to be a strong piece of work in support of the mobility subarea.

Reviewer 2:

The reviewer noted that the project supports the EEMS subprogram objectives and provides an essential cohesive metrics framework for evaluating mobility technologies.

Reviewer 3:

The reviewer commented that the project is highly related to the EEMS area. MEP does provide a quantitative measure useful for public agencies, especially on planning purpose.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented that the project is near completion, and it appears that there were sufficient resources to accomplish the current scope of work. It appears that the researchers have some additional ideas that would be good candidates for future funding.

Reviewer 2:

The reviewer stated that the organizational and geographic surface area of the impacts of this project are growing each year, it likely deserves more resources to deliver its potential benefits.

Reviewer 3:

The reviewer commented that from the time, funding, and partnership perspective, the reviewer thinks the resources of this project is sufficient. It would be great if some transportation data providers and public (not agencies) can be involved to provide some feedback.

Presentation Number: EEMS100
Presentation Title: Dynamic Curb Allocation
Principal Investigator: Nawaf Mohammed (Pacific Northwest National Laboratory)

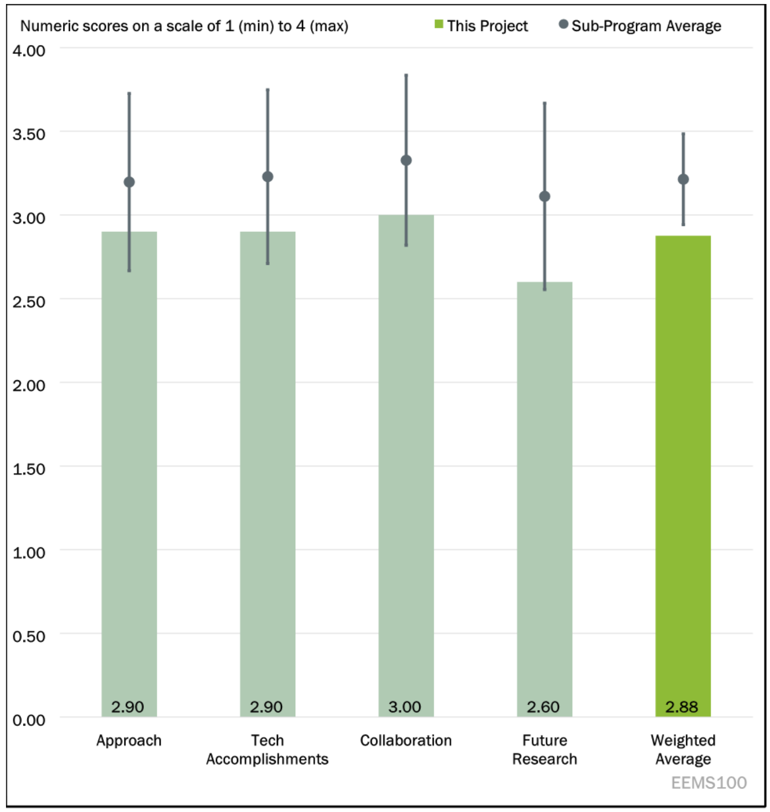

Figure 4-14 - Presentation Number: EEMS100 Presentation Title: Dynamic Curb Allocation Principal Investigator: Nawaf Mohammed (Pacific Northwest National Laboratory)

Presenter

Nawaf Mohammed, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 80% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 20% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer commented that the loss of real-world validation opportunities in Seattle and San Francisco seems to be a major blow. The reviewer mentioned appreciating the pivot to use SeaTac data, but it is still limited. The reviewer stated that curbside charging is mentioned several times but sees nothing in the project design that would help address where/whether/how curbside charging in the right of way should be encouraged.

Reviewer 2:

The reviewer stated that the approach is well designed with implementations for centralized curb control complete as well as integration with communications platform for tech demo. Outreach to new curb stakeholders interested in results successful.

Reviewer 3:

The reviewer commented that a lot of work has been done to overcome the fact that obtaining the level of data for this type of project is very difficult. Due to all the changes, it is clear that project had to accomplish a lot in a compressed timeline. However, the foundation for the work, which is data, doesn’t seem to be well understood. If the data is not well understood assumptions could be made as well as interpretations of the final results that might be inaccurate. For example, in the area of commercial vehicles, the characteristics of those vehicles do not seem to be clear to the researchers. Implications for delivery vans, local short haul, and Class 8 tractor trailer deliveries are completely different and should be accounted for.

Reviewer 4:

The reviewer commented that the project combines an interesting combination of micro and macro scale curb simulation development, optimal online/market-based curb allocation controller development and validation through municipal operator and traffic sensor stakeholder engagement, and integration with communications platforms to provide real-time curb occupancy information. The project is well planned over a three year completion duration. The project addresses the need for data-driven curb management assessment and mitigation tools.

Reviewer 5:

The reviewer stated that the project is well-designed to quantify and understand how curb use and management may impact overall transportation efficiency and energy consumption. This is a potentially important but not fully understood part of the larger mobility system.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer stated that the modeling seems useful, but it seems this project is still a long way from providing actionable tools for local governments. The optimization algorithm is opaque (e.g., how is climate valued? how are economic values of different curb uses valued?) and would need to be much clearer for local governments to be willing to use these tools.

Reviewer 2:

The reviewer commented that the web-based communications platform developed to display curb occupancy in real-time as well as curb value function models demand in time and space. Identified key inputs for objective function on destinations of interest or centers of demand and arrival rate of vehicles. Optimal curb allocation controller integrated with communications platform as a servable model to display curb allocation based on vehicle type. Also developed model predictive control-based automation of diversionary signs at airports. Automated interventions can save 20 to 80 cumulative vehicle-hours every hour where deployed.

Reviewer 3:

The reviewer noted that the project is close to completion, per timeline, but there are a lot of data verification and validation that is needed (based on the question-and-answer session). The objectives of the project are important to accomplish, so they might benefit from additional time to ensure the data is verified properly (e.g., vehicle type implications) and accurately validated.

Reviewer 4:

The reviewer commented that the research team achieved several accomplishments in the last reporting period. They have revealed that that optimal, dynamic curb zoning is a mixed integer dynamic programming problem. The team also demonstrated a web-based communications platform that displays curb occupancy in real-time. The results also included a curb space value function to model demand in time and space, with curb space value prediction over time and curb locations for three different types of allocations. The team also developed an optimal curb allocation controller integrated with a communications platform as a servable model to display curb allocation based on vehicle type and demonstrated a model predictive control (MPC) based automation of diversionary signs at airports.

Reviewer 5:

The reviewer noted that the project team has made good progress in this project and has successfully mitigated issues such as the unavailability of validation data (by pivoting to alternate ground-truth data). However, it is not evident that planned integration of different components of the project (e.g., VISSIM micro-simulation and BEAM meso-simulation) has been successful. This integration was planned to be through the development of new fundamental diagrams, which was not adequately discussed in the presentation. Additionally, it is not clear that data from the specific use-case addressed by the project (i.e., airport traffic) is extrapolatable to other locations.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer commented that this project would be much stronger and more actionable, in my opinion, if it had been built with strong participation from local governments and appropriate local government organizations of local planners and officials. Their omission feels like a major oversight. The reviewer would also like to have seen stronger industry engagement from companies using the curb (gig delivery companies, parking management firms, commercial delivery companies, etc.) as well as other connected city technology providers beyond just Lacuna.

Reviewer 2:

The reviewer noted that the collaborating institutions form a uniquely broad set of curb stakeholders (cities, commercial fleets, and startups). Having project-wide biweekly meetings with high frequency task-specific meetings between collaborators as needed. Strong team members and task: Pacific Northwest National Laboratory is responsible for developing fundamental diagram learning techniques, research and implementation of dynamic curb control algorithms, communications platform development, and managing systems integration. University of Washington Urban Freight Lab & Penn State are responsible for microscale simulator design. Lacuna is an urban mobility startup developing the communications systems and data pipeline utilizing an open-source Mobility Data Specification (MDS). Lawrence Berkeley National Laboratory are the developers of the mesoscopic transportation system simulator, which will accept contextual delay diagrams to measure system wide energy impacts of curb configuration. National Renewable Energy Laboratory are the developers of SMART 1.0 curb performance metrics that form the basis of an objective function for online optimization of curb allocation.

Reviewer 3:

They stated that great work has been performed in many aspects of the project and among the current collaborators given the importance of data as the foundation for the full project. Having several locations (once San Francisco and Seattle were not able to continue) included as part of the project and pay for the installation and pilot data might have assisted in the process of securing the data as well as ensuring the information obtained was the one needed for the models. Working together with the locals to develop a data dictionary of what is needed vs obtained ahead of time is very important for the success of this type of project.

Reviewer 4:

The reviewer commented that the project maintains a strong partnership of collaborators made up of other national laboratories (PNNL, LBNL and NREL), academia (University of Washington Urban Freight Lab and Penn State University) and industry (Lacuna, and urban mobility start-up). The researcher provided a nice description of partner roles on the project, and the partners provide collaborative value in terms of project objectives.

Reviewer 5:

The reviewer stated that collaboration within the project team is strong, with close coordination between PNNL, other national laboratories, universities, and an industry partner. Collaboration with stakeholders is limited to Miami International and Seattle-Tacoma International airports. Additional collaboration with local municipalities would strengthen the impact of the research.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer suggested that future research include developing more user-friendly and user-adjustable tools, and outreach to test the attractiveness of such tools with local governments. The reviewer also feels renewing efforts to validate model results with more robust data sets, not just one airport's data, would be critical for these models to be credible.

Reviewer 2:

The reviewer commented that this project is well positioned to consider multiple curb use cases such as speed-flow results suggest curb activity may only impact traffic flow in extreme cases, such as in ports, transit hubs, sporting events. They have considered speed-flow impacts in cases such as airport terminal-ways, as illustrated in the work on signs, by bringing the Port of Seattle and SeaTac on as working group members and analyzing their traffic flow and use data, to which our control solution is applicable. Currently they are coordinating with SeaTac in deploying the automated control to reduce congestion at the airport terminals. Curbside EV charging can also have substantial impacts on traffic as it may change drivers' routes to access EV charging. Utilizing cost-effective ways to detect curb occupancy and enforce curb management policies, reducing the need to deploy costly sensing equipment.

Reviewer 3:

The reviewer commented that too many questions remain in the current scope to expand the scope to other topics. The future research is focused on expansions instead of optimizing and overcoming the currently proposed work.

Reviewer 4:

The reviewer stated that proposed future research is leveraging prior work and will be considering several curb use scenarios, including airport terminal-ways based on SeaTac deployment of variable message signs control, curbside EV charging impacts on traffic, and cost-effective curb occupancy detection methods.

Reviewer 5:

The reviewer commented that several remaining areas for which there is limited information were highlighted in the presentation, suggesting that there are opportunities for additional research. As this project comes to completion, it is unclear if the team intends to pursue any additional work.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer stated that curb management is a critical issue that EEMS should continue to address.

Reviewer 2:

The reviewer noted that most technical deliverables are on schedule and municipal engagement continues at an aggressive pace. The Optimal Curb allocation controller has been integrated with a web-based communications platform as a servable model to display dynamic curb allocation based on vehicle type. The curb working group has grown to include Miami, Portland, and the Port of Seattle. The project team is working directly with

SeaTac airport to validate microsimulation model and deploy automated control to reduce traffic congestion. Reduced traffic congestion always improves the air quality and fuel economy of the vehicles affected.

Reviewer 3:

The reviewer stated that this topic is extremely important and could assist greatly in the future as more information (e.g., EV charging) is connected to the parking spaces for dynamic curb allocation. The reviewer suggests investing in it, but instead of looking at quick expansion focus for now, on ensuring that the existing work and capabilities are accurate and build on that.

Reviewer 4:

The reviewer commented that this project is relevant to the VTO EEMS program research portfolio involving transportation systems, traveler choice, and mobility energy productivity. The project focuses on trying to better understand urban curb management from the prospective of new users and new technologies and its impacts on urban congestion.

Reviewer 5:

The reviewer noted that the project addresses a research topic that is highly relevant to the EEMS portfolio, and endeavors to both understand the impacts of curbspace allocation, and design solutions to optimize it.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented that the budget seems large for what is primarily a modeling exercise without equipment investments—and for the products produced to date.

Reviewer 2:

The reviewer noted that all the objectives appear to have been met.

Reviewer 3:

The reviewer commented that this project is towards the end of its performance period. It still has significant work ahead. If a follow-up project is considered the reviewer mentioned to focus on ensuring the data is appropriately collected and understood to ensure the goals for the project are appropriately accomplished. The reviewer stated this is a very hard topic and finding partners to produce the appropriate dataset is not trivial. Treating this as a pilot and now trying to build on those lessons learned would be appropriate.

Reviewer 4:

The reviewer commented that project resources appear to be sufficient for completing the remaining 15% of project activities by the end of the fiscal 2023 year. Milestone 9 was delayed due to data limitations, but the team shifted to available data from airports to allow for completion of the validation work.

Reviewer 5:

The reviewer stated that given the scale and scope of the project, the funding resources allocated to the work are appropriate.

Presentation Number: EEMS101
Presentation Title: RealSim, An Anything-in-the-loop Platform for Mobility Technologies
Principal Investigator: Yunli Shao (Oak Ridge National Laboratory)

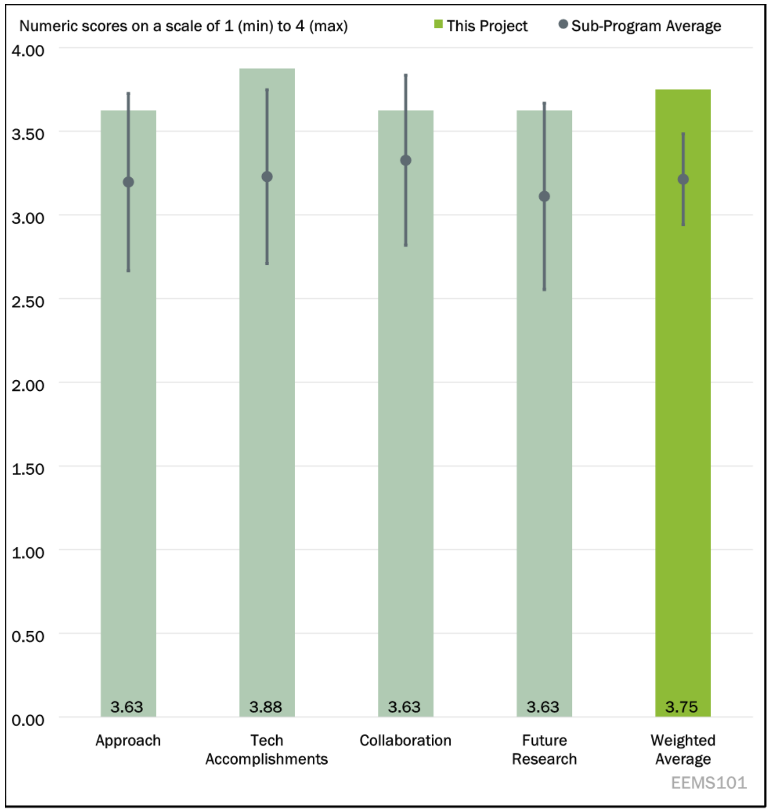

Figure 4-15 - Presentation Number: EEMS101 Presentation Title: RealSim, An Anything-in-the-loop Platform for Mobility Technologies Principal Investigator: Yunli Shao (Oak Ridge National Laboratory)

Presenter

Yunli Shao, Oak Ridge National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer stated that the team's approach includes the following key building blocks: (1) Sensor development for XIL and virtual environment 2.0; (2) VPPG XIL co-simulation; (3) ANL Perception and Connectivity Activity; (4) RealSim platform development and digital twins; and, (5) Validation using current on-road EEMS projects. These are all well-motivated and the approach is sound.

Reviewer 2:

The reviewer commented that the project is well designed to accomplish the task of creating higher fidelity virtual environments.

Reviewer 3:

The reviewer believed the technical tasks outlined and the work performed so far are addressing technical barriers related to this problem adequately.

Reviewer 4:

The reviewer commented that overall, the approach of emulating infrastructure and traffic to test vehicles or optimization techniques virtually is the way to go as fielding multiple test CAV's with real time control and coordination is difficult. The research team has taken a good approach on digital twin, virtual sensors and robot operating system (ROS) bridge over to hardware. Just great to see all the pieces come together and show a successful demonstration.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer stated that the team's key technical accomplishments may be summarized as follows:1. Fully operational raw sensor emulation of lidars, radars, cameras, etc.; 2. Interface to XIL has been developed as an open-source tool with plug-and-play co-simulation capabilities with VISSIM/SUMO, IPG/CARLA, etc.; 3. ANL's APaCK-I/V units are actively gathering on-road data for digital twin creation.; 4. A streamlined workflow has been established to create digital twins using on-road data and existing databases.

Reviewer 2:

The reviewer noted that the tasks are complete or on-track. Key techniques like virtual sensing and combining real and virtual data have been demonstrated.

Reviewer 3:

The reviewer commented that the work seems progressing as scheduled.

Reviewer 4:

The reviewer stated the so many tools combined and homologated into a coherent and unified workflow for CAV demonstration is very difficult to do and the team has done this and demonstrated success virtually and physically in small road experiments. This is fantastic to see. The collaborations and connections with other EEMS projects no doubt helps to make this a success and is a reflection of the project leadership team.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer commented that the partnerships and collaborations have been healthy between ANL, ORNL, IPG Automotive, and Ford Motor Company. ANL is strongly focused on the prototype ALPACA unit. ORNL is executing numerous EEMS projects (Real-Twin, various FOAs, Integrated Speed & Signal Control, Virtual Physical Proving Ground, Regional Mobility Ctwin). IPG is collaborating with ORNL via software support for sensor modeling & emulation, as well as ROS and Autoware for XIL. Ford is in a CRADA with ORNL to use real-sim capabilities and XIL testing to provide feedback to the rest of the project.

Reviewer 2:

The reviewer noted there was an excellent mix of collaborators from industry and national laboratories.

Reviewer 3:

The reviewer stated that having IPG and Ford as partners on this project is vital. Coordination with them is demonstrated in their contribution to the performed and on-going tasks.

Reviewer 4:

Good to see IPG and Ford as collaboration partners and consumers/users of the real-sim technology.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer commented that the proposed future research plan is sound and involves the following objectives:1. Fully integrate sensor emulation and XIL with CARLA; 2. Refine Real-Sim XIL interface and release as an open-source XIL toolchain for mobility studies; .3. Data collection for digital twin for Greater Chicagoland Roadways; 4. Exercise real-sim for experimental validation on various EEMS projects; and 5. Run verification test of Real-Sim XIL with on-road vehicle testing in various EEMS projects.

Reviewer 2:

The reviewer commented that the appropriate follow-on tasks to show off the digital twin capabilities are being developed.

Reviewer 3:

The reviewer stated that yes, the project clearly defined the purpose of future work.

Reviewer 4:

The reviewer commented that the proposed research work related to project tasking is appropriate and has a purpose to fully accomplish the project goals. The likelihood of success is high, and the team will achieve their targets. The synergy with other EEMS projects helps to ensure this success.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer commented that this project enables a system of systems approach for understanding vehicles equipped with ADAS and "autonomous" driving in various traffic environments. These types of studies can lead to novel strategies for transportation/mobility efficiency optimization, thereby reducing CO_2.

Reviewer 2:

The reviewer commented that the digital twin of the vehicle environment is a key tool for assessing CAV technologies in a safe realistic environment. CAVs are a key technology for potential transport system energy reductions, a key DOE VTO goal.

Reviewer 3:

The reviewer identified relevance to EEMS, Analysis and Electrification.

Reviewer 4:

The reviewer stated that the work aims to provide sensor emulation and digital twin in support of other EEMS XIL initiatives to demonstrate CAV operability for energy savings, so it clearly is aligned with DOE VTO objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that total funding of $3.58 million for 3 years is adequate for the stated objectives.

Reviewer 2:

The reviewer noted that the tasks are complete or on schedule with the available resources.

Reviewer 3:

The reviewer commented that the project resources seem adequate, and the team has been well integrated with current EEMS projects throughout.

Reviewer 4:

The reviewer commented that the resources are sufficient.

Presentation Number: EEMS102
Presentation Title: AI-Engine for Optimizing Integrated Service in Mixed Fleet Transit Operations
Principal Investigator: Philip Pugliese (Chattanooga Area Regional Transportation Authority)

Presenter

Philip Pugliese, Chattanooga Area Regional Transportation Authority

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

80% of reviewers felt that the project was relevant to current DOE objectives, 20% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

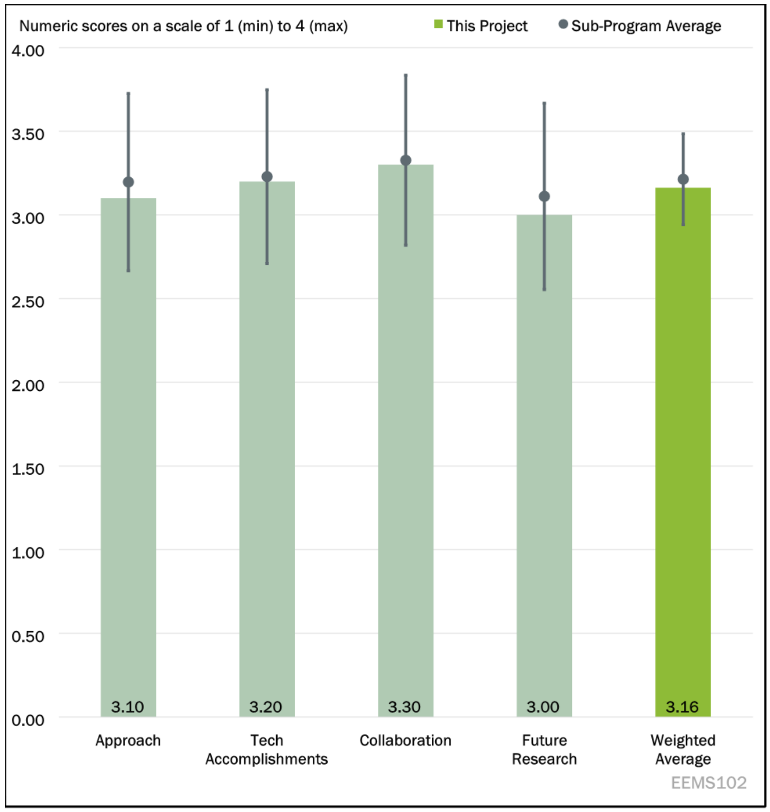

Figure 4-16 - Presentation Number: EEMS102 Presentation Title: AI-Engine for Optimizing Integrated Service in Mixed Fleet Transit Operations Principal Investigator: Philip Pugliese (Chattanooga Area Regional Transportation Authority)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer stated that the optimization of transit activities can be important in reducing energy use through improved mobility. The potential application of AI in this area is an interesting topic. This project has a lot of different elements to it, but it appears that the design is coming together/completion, and that the timeline for the remainder of the project is doable.

Reviewer 2:

The reviewer noted that only one of the three specific milestones were completed.

Reviewer 3:

The reviewer commented that this project is complex with several considerations being made in order to ensure that the technical barriers are addressed. The project is end-user-focused and careful thought has been given to developing the outreach and education based on survey results that were administered in 2022. Twenty-five percent (25%) of the project remains and the team has 1 year to complete it. The timeline seems reasonable.

Reviewer 4:

The reviewer stated that the study laid out ambitious objectives for solving many of the routing problems for a mixed-service transit system. And while some of the data points to potential savings from the approach used in the study, the presentation of data wasn't comprehensive enough to clearly understand whether the study's approach generates enough savings to merit replication in other settings. Next year's presentation should include more service metrics. The most interesting findings were on the technical backup slides. The analysis demonstrated that services designed to serve those with the greatest needs can be less efficient. We've known this intuitively for decades, but it is good to see support in this research. It will be interesting to see how this issue is addressed in the last year of this project.

Reviewer 5:

The reviewer noted that based on the material presented at AMR, the project approach seems solid for this stage of the project, and the reviewer does not have any concerns about the project team's approach to addressing the identified technical barriers.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer noted that this project is about 75% complete, and it appears that the plans for the final elements are nearly approved for implementation. It appears to be reasonable that the project will be completed over the next year.

Reviewer 2:

The reviewer commented that from the results it seems that the team has simulated a reduction to energy use that is in line with their goal. However, the reviewer would agree with one of the respondents of the survey that an overall energy reduction on the transit system shouldn't be the goal but an overall reduction in energy per user should be.

Reviewer 3:

The reviewer stated that for the most part, the team seems to be moving the project along. The reviewer mentioned it seems as though the team is experiencing some difficulties with origin-destination (OD) data collection and operational constraints. The reviewer mentioned not seeing a description of the resolution for this but did see that there is a pending resolution to address this issue.

Reviewer 4:

The reviewer noted that it seems that some critical information about the operating results is missing, including those items identified as under development in the presentation.

Reviewer 5:

The reviewer stated that the project appears to be on-track compared to the project plan on slide 5. Their only concern is related to the challenges with data collection. How will challenges with OD data collection be addressed? Is there a way to complete the project if only data are collected on only 50% of the fleet?

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer noted that the team has good coordination and cross collaboration, including a transit agency, community groups, and universities and national laboratories. It appears that the researchers have done solid work in engaging in the community to determine the needs and who most requires the services.

Reviewer 2:

The reviewer commented that one of the major milestones is incomplete due to "vehicle data transfers." My assumption is this transfer is from one of the members of the project team to another.

Reviewer 3:

The reviewer stated that team collaboration seems strong despite the size of the team. The partners in this project are all high-profile entities. It was not apparent which partner made which contributions to the project.

Reviewer 4:

The reviewer noted that a different reviewer last year asked about community collaboration. It might be more helpful if the actual results of that collaboration were laid out.

Reviewer 5:

The reviewer stated that there seems to be adequate collaboration across the project team. The reviewer mentioned, moreover that they applaud the efforts to understand community needs through community engagement.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer commented that it will be interesting to see the potential benefits that might be achieved as the group continues to implement this program into the transit fleet and the more complete integration and intervention strategies for Budget Plan 3. It appears that the future research should be completable within the timeframe, given the time extension noted.

Reviewer 2:

The reviewer stated that the future research is not clear beyond the implementation of paratransit. The parking and Siemens integrations aren’t clear. The reviewer would also not consider micro transit and fixed route as multimodal.

Reviewer 3:

The reviewer commented that while there were some pending accomplishments and future research listed, it was difficult to distinguish what was a pending accomplishment and what was future research. It would have been helpful to provide additional context to future research and what the goals are for that.

Reviewer 4:

The reviewer noted that the future research slide lays out a path toward project completion.

Reviewer 5:

The reviewer commented that in the reviewer only slides one of the remaining challenges is that the intervention strategy success will be subject to public acceptance. The project team did a good job of going out of their way to meet the community where it was for the survey (e.g., available online and paper format, recruiting at bus shelters, and through different organizations that tend to serve low-income community). But the presentation also mentions the CARTA GO app. Has the project team thought about whether or not the community they are targeting will have access to a smartphone (or data plan) that enables them to use an app like CARTA GO? Or are there other ways to reach them with intervention strategies if they do not have access to technology solutions?

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer noted that the application of computer modeling to mobility problems is center piece of DOE objectives in the mobility area. Overall, the project appears to align well with the overall VTO subprogram objectives.

Reviewer 2:

The reviewer commented that this project contributes to the VTO EEMS strategic goal of Identify and support early-stage R&D to develop innovative technologies that enable energy efficient future mobility systems.

Reviewer 3:

The reviewer stated that this project supports the overall VTO subprogram objectives.

Reviewer 4:

The reviewer noted that the project aims to develop improved energy efficiency for transit agencies with multiple services.

Reviewer 5:

The reviewer was not clear as to why this project was funded utilizing a customized routing algorithm. There are commercialized products that optimize routing. If VTO wanted to understand the energy savings of using something that is already readily commercially available or benchmarking a commercially available product against something more optimized that might make more sense.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer noted that the project is near completion, and it appears that there were sufficient resources to accomplish the current scope of work. It is noteworthy that the researchers have co-funding at a 20–25% level of DOE funds. The researchers provide some ideas for future work, but it would be interesting to see if these efforts can be expanded to other areas throughout the country.

Reviewer 2:

The reviewer stated that there is not much information on resourcing here, but it seems to be sufficient.

Reviewer 3:

The reviewer commented that the project team has put together an impressive number of resources and a website. Several members of the team have published papers that relate to this project and its outcomes. Additionally, the project team has a website with additional resources and updates.

Reviewer 4:

The reviewer noted that the resources appear to be sufficient to complete the project, though some delays in technical activities may lead to concerns that resources are insufficient for the technical needs.

Reviewer 5:

The reviewer commented that the resources available for this project appear sufficient to meet the stated milestones.

Presentation Number: EEMS103
Presentation Title: Transit-Centric Smart Mobility System for High-Growth Urban Activity Centers, Improving Energy Efficiency through Machine Learning
Principal Investigator: Jinhua Zhao (Massachusetts Institute of Technology)

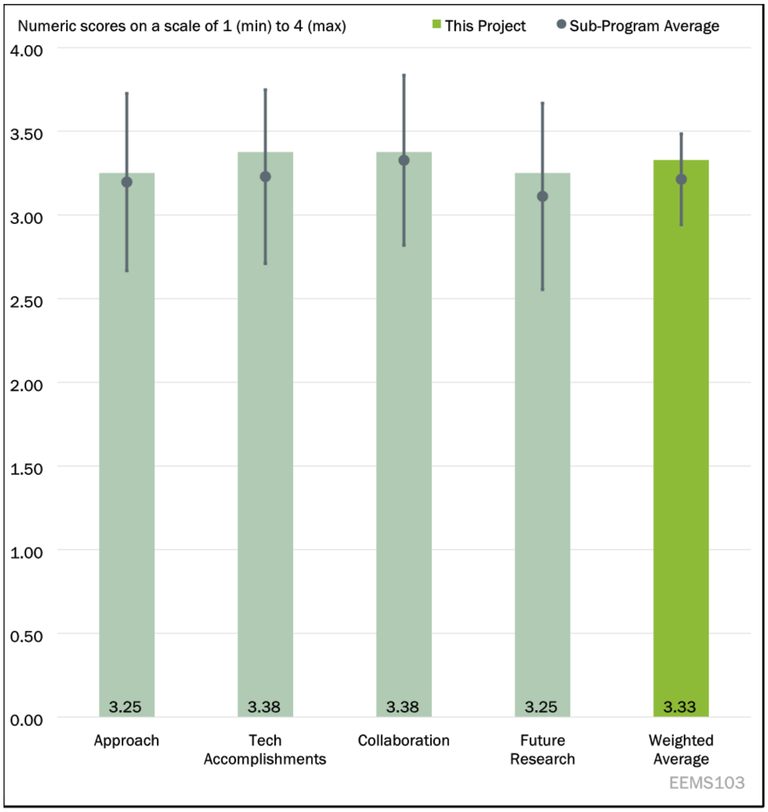

Figure 4-17 - Presentation Number: EEMS103 Presentation Title: Transit-Centric Smart Mobility System for High-Growth Urban Activity Centers, Improving Energy Efficiency through Machine Learning Principal Investigator: Jinhua Zhao (Massachusetts Institute of Technology)

Presenter

Jinhua Zhao, Massachusetts Institute of Technology

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

75% of reviewers felt that the project was relevant to current DOE objectives, 25% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer commented that the Transit-Centric Smart Mobility System (TSMS) approach seems like a small variable in the larger problem of increasing ridership satisfaction, driver training and promoting transit solutions. The presenter did little to communicate the benefits on a larger scale.

Reviewer 2:

The reviewer noted that all objectives are 100% complete.

Reviewer 3:

The reviewer commented that this study is endeavoring to use technological advances to address long standing bus transportation issues. The research to date has great merit and an approach that is producing measurable benefits. The reviewer will be keenly interested in seeing the results of an expanded pilot.

Reviewer 4:

The reviewer stated the proposed math and solutions appear to be addressing real issues within the public transportation sector.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer commented that the project has made progress to plan which has resulted in progress, although would also like to see a statistical analysis of the TSMS data gathering process.

Reviewer 2:

The reviewer commented that the project team provided detailed outcome-based achievements for the users of the transit system. These improvements will help both users and Chicago Transit Authority (CTA). The only thing that kept this from being outstanding is that the presentation did not discuss or provide examples of interventions that were made. It said the system made recommendations to supervisors but did not say what the recommendations were that caused such a dramatic improvement.

Reviewer 3:

The reviewer stated that by working effectively with stakeholders, the study appears to be developing algorithms and communications protocols that are substantially improving transit service on a test CTA bus corridor. Expansion to other CTA corridors is planned.

Reviewer 4:

The reviewer noted that the material addressed concerns of the previous reviewers.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer commented that the number of partners is limited, however it appears collaboration with CTA is excellent.

Reviewer 2:

The reviewer stated that the team was heavily embedded with the partner agency in their operations center.

Reviewer 3:

The project demonstrated effective regular communication with key stakeholders, especially the CTA. Consultation with low-income and minority communities might be helpful as expansion to other travel corridors is contemplated.

Reviewer 4:

The reviewer noted that the presentation successfully addressed previous reviewer comments.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer commented that a good list of future research is provided for this activity, but perhaps a deeper understanding of the issues is required to generate a more robust solution to transit bus issues.

Reviewer 2:

The reviewer would have liked to have seen more details about exactly which routes and weeks were going to be used in the future. The reviewer would have liked to have known based on the lessons learned from the pilot period, what recommendations did the team have to CTA as to how to best select the next locations to either test the impact or maximize the total impact of the project.

Reviewer 3:

The reviewer noted that future planned work will lead to project completion and dissemination of the information to national stakeholders.

Reviewer 4:

The reviewer appreciated the statistics provided on Slides 7 and 8. While the system and math on Slides 9–12 are addressing the problems seen at the intended user.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer stated that there was a good list of future research provided for this activity, but perhaps a deeper understanding of the issues is required to generate a more robust solution to transit bus issues.

Reviewer 2:

The reviewer commented that this project not only meets VTO goals but is still very relevant to the circumstances on the ground for transit agencies.

Reviewer 3:

The reviewer commented that the project demonstrates improved transit customer service with lower energy consumption.

Reviewer 4:

The reviewer noted that relevance is well defined on Slide 3.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The commented that the resources appear adequate since no issues were highlighted.

Reviewer 2:

The reviewer stated that the future work plan is scalable to achieve the goals of the project.

Reviewer 3:

The reviewer stated that the resources for the project seem to be sufficient for project completion.

Reviewer 4:

The reviewer commented that the $1.75 million for total project funding listed on Slide 2 should be sufficient to complete the remaining 35% of the project.

Presentation Number: EEMS104
Presentation Title: Increasing Affordability, Energy Efficiency, and Ridership of Transit Bus Systems through Large-Scale Electrification
Principal Investigator: Ziqi Song (Utah State University)

Presenter

Ziqi Song, Utah State University

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

80% of reviewers felt that the project was relevant to current DOE objectives, 20% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

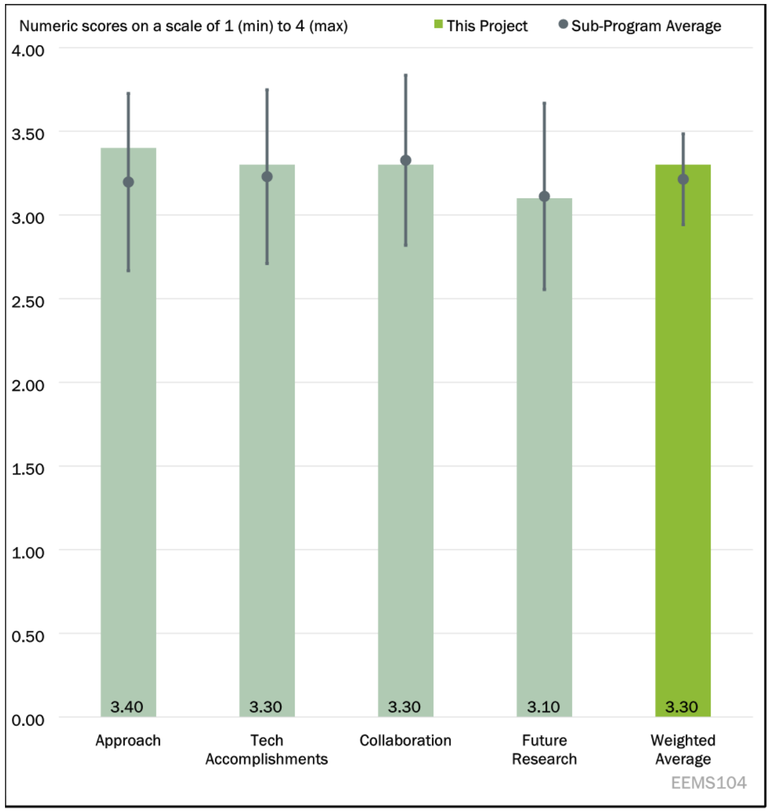

Figure 4-18 - Presentation Number: EEMS104 Presentation Title: Increasing Affordability, Energy Efficiency, and Ridership of Transit Bus Systems through Large-Scale Electrification Principal Investigator: Ziqi Song (Utah State University)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer commented the approach is multi-dimensional and should have impact for improving bus service cost.

Reviewer 2:

The reviewer stated that the three-pillar approach: affordability, mobility, and efficiency, includes initial modeling and refinement with real-world data. Initial implementation has two phases of refinement with partners and external entities. Discussion with electric utilities which have a major impact on demand charge (and charging cost in general) and therefore cost per mile. The reviewer suggests including an alternative scenario or two for demand charge configurations and comparing them to the optimization results. Continued discussion with electric utilities would be beneficial. Lack of analysis for how fuel cell electric bus (FCEB) adoption by transit agencies might affect the distribution of routes that battery electric buses (BEBs) are expected to take. A bit out of scope perhaps, but important to keep FCEBs in mind as they are an option for transit agencies that could help with longer routes (or backup as the speaker noted).

Reviewer 3:

The reviewer commented that the project demonstrated electrified bus operations, and strategies to reduce operating costs, measure grid impact, and measure transit rider perceptions. The study is contributing meaningfully to our understanding of bus electrification. Including into the approach, both technical innovation and a better understanding of customer needs, is probably the best direction toward successful transit adoption of electrification.

Reviewer 4:

The reviewer commented that given the project's focus on creating a planning model to help transit agencies deploy electric buses, the barriers addressed in the approach seem sound. The model created considers the total cost of ownership, from purchase price to charging considerations which can help transit operators understand the full investment of making the switch.

Reviewer 5:

The reviewer noted that the approach is well thought out.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer noted that the project is on schedule.

Reviewer 2:

The reviewer commented that there were some delays from COVID but are back on track analyzing survey data. Modeling has been conducted and awaiting survey analysis for refinement before implementation in real world. Planning implementation with three different types of bus chargers and two locations with multiple bus routes and over 10 BEBs.

Reviewer 3:

The reviewer stated that the project has made substantial progress toward addressing the issues transit agencies are identifying as electrification accelerates. The project appears on track to address the technical issues identified in the presentation.

Reviewer 4:

The reviewer commented that the progress made in the planning modeling tool has been significant and has exceeded the milestones set by the project in terms of the number of routes and buses planned for as well as the reduced cost of ownership. Refinement and analysis of the outputs has also been successful in meeting or exceeding project milestones. The reviewer believes the work around bus rider surveys seems important but wasn't able to obtain enough information about the methodology to assert whether the approach and resulting outcomes were aligned with what was intended.

Reviewer 5:

The reviewer noted that there was a well detailed plan.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer stated that a good list of partners is provided, however the collaboration, communication and responsibilities are not clearly discussed.

Reviewer 2:

The reviewer commented that the project team has partnered with NREL/ANL/Purdue who are leading different aspects. Seem to coordinate well with clear differentiation of tasks.

Reviewer 3:

The reviewer stated that the study is fostering coordination across a variety of stakeholders, notably including support for grid analyses. Inclusion of both transit-user and general-population surveys is an important step in improving transit agencies responses to emerging transit agency-energy system issues.

Reviewer 4:

The reviewer noted that the mix of partners (national laboratories, transit agencies, research universities, utilities) is appropriate and given the small team on this project, they all contribute significantly to the project overall. The reviewer would have liked to see additional partners involved that represent riders such as those that work to improve ridership on transit and understand the barriers to riding that might have contributed to the analysis completed by the project team.

Reviewer 5:

The reviewer suggested that the project team consider a larger fleet and test cases to demonstrate real world applications.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer stated that given the size and complexity of the problem, the list of proposed future research should be better documented and contain more ideas.

Reviewer 2:

The reviewer stated that integrating real-world data will be a good benefit to the project and the project is set up to include this. Further long- and short-term economic and energy analysis is also germane. Marketing plans are a nice addition, though it is unclear what skills or experience the team has in this area. Commendable task, though.

Reviewer 3:

The reviewer noted that expansion of the pilot and the results of the general population survey are important future steps for the project.

Reviewer 4:

The reviewer would have liked to have seen more collaboration with potential transit partners in other cities. The reviewer was pleased to hear that the presentation mentioned that the team is working to expand the model with more data inputs and are talking with utility NV Energy to do so. The reviewer mentioned that the presenter did not have time to go into much detail about the other future plans for research but those provided on the slide are appropriate. The reviewer is curious about the one to "Design marketing activities in partnership with new mobility providers." The reviewer is not clear on how this connects to the modeling work or other project tasks.

Reviewer 5:

The reviewer commented that the proposed future research applies to larger test cases in worst case scenario, drivability, and extreme charging conditions.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer stated that the project does not support all VTO objectives.

Reviewer 2:

The reviewer commented that the project is clearly relevant as increased mass transit usage would reduce energy and emissions per person mile traveled.

Reviewer 3:

Bus electrification is an important strategy to reduce transportation system greenhouse gases. The study improves our understanding of the issues surrounding bus electrification and strategies to address those issues.

Reviewer 4:

The reviewer commented that given a core facet of EEMS is to conduct early-stage research and development to create knowledge, insights, tools, and solutions to increase mobility energy productivity, this project is well aligned with the objectives. The electric transit space is very young and many transit operators are only comfortable taking on new technologies once they are proven and if they can fully understand the total cost of ownership (TCO). This project seeks to demystify some of this for transit providers while also providing data to support the financial picture of making that transition.

Reviewer 5:

The reviewer stated that there were more and more large vehicle applications.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said that the resources are adequate.

Reviewer 2:

The reviewer commented that the inclusion of Utah Transit Authority and TriMet transit agencies is a clear value in this project, providing buses, routes, and chargers in the project. The modeling and analysis are well-handled by the core project partners.

Reviewer 3:

The reviewer stated that the project appears to be moving forward adequately with the resources available.

Reviewer 4:

The reviewer commented that the resources seem sufficient to me given the focused scope of this project.

Reviewer 5:

The reviewer commented that it is on track.

Presentation Number: EEMS105
Presentation Title: Energy Optimization of Light and Heavy Duty Vehicle Cohorts of Mixed Connectivity, Automation and Propulsion System Capabilities via Meshed V2V-V2I and Expanded Data Sharing
Principal Investigator: Darrell Robinette (Michigan Technological University)

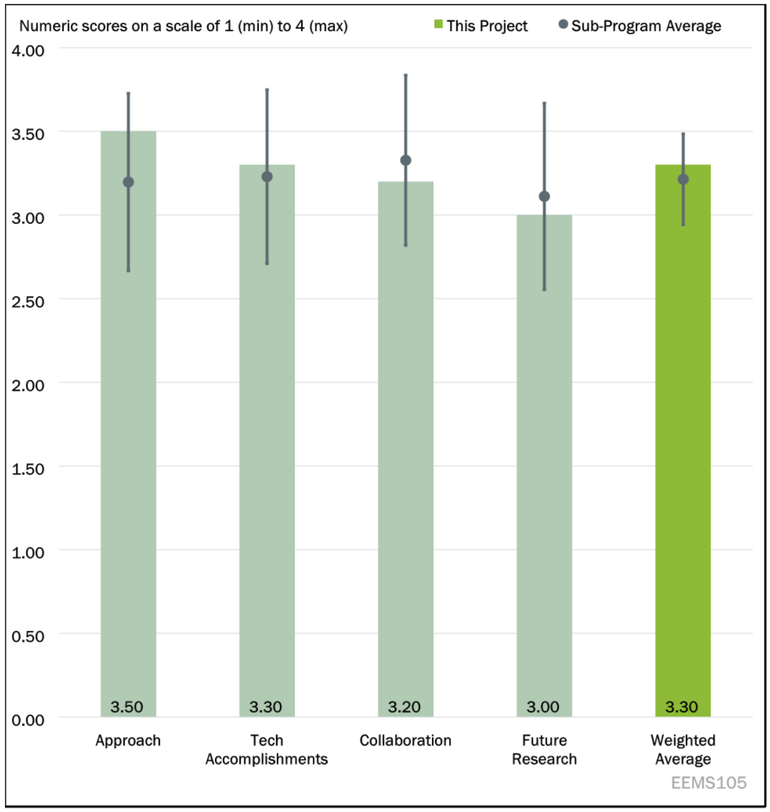

Figure 4-19 - Presentation Number: EEMS105 Presentation Title: Energy Optimization of Light and Heavy Duty Vehicle Cohorts of Mixed Connectivity, Automation and Propulsion System Capabilities via Meshed V2V-V2I and Expanded Data Sharing Principal Investigator: Darrell Robinette (Michigan Technological University)

Presenter

Darrell Robinette, Michigan Technological University

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

80% of reviewers felt that the project was relevant to current DOE objectives, 20% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 80% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 20% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer stated that the project does an excellent job of addressing the possible synergy between automation and connectivity.

Reviewer 2:

The reviewer noted that two of the items in Phase 3 are not complete.

Reviewer 3:

The reviewer noted that the project becomes a viable candidate to improve energy efficiency across the system in the near term if it is possible to create a variant of the design with nudged human-driven connected vehicles. The results and technical approach are excellent. It is interesting that the actual physical CAV cohort testing rendered energy savings greater than those predicted in simulation; curious on what might be responsible for the under-prediction of energy savings—a rare and excellent problem to have. Once simulation results are validated by the test track results, many more studies can be conducted with less live testing required. Use of the design of experiment (DoX) to analyze the trade space and optimize the cohort and timing was an excellent approach and yielded valuable insights. The "counterintuitive vehicle ordering" that DoX identified as most efficient may be similar to dimples on golf balls in that the dimples (or initial vehicle) create a turbulent boundary layer that results in aero flows closer to the ball and less drag. The results run counter to the early project results: since cohort energy use is dominated by the HD vehicle, the HD vehicle was initially positioned first to make sure it always went through on a green. Awesome insight based on simulation results—counterintuitive ones are the most useful to find because they would not have been found otherwise. Also, BEVs being out front may be appealing to those drivers (better visibility). It is unclear if this logic holds for HD trucks—should they positioned at front, end, or middle of queue?

Reviewer 4:

The reviewer commented that technical barriers described in the project overview provide a clear problem statement for the project and that these technical barriers are addressed well within the project. The project has already demonstrated that connectivity along with automation can reduce energy consumption as well as reduce travel time which are both goals for the EEMS program.

Reviewer 5:

The reviewer commented that the presentation implies that all barriers have been successfully addressed as Slide 2 says that work is 100% by June 30, 2023, but by the time of the presentation there was work yet to be accomplished.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer commented that technical progress has been quite good. In fact, the detailed modeling work is excellent, and the “Assumptions” slide was very good. However, several factors have been ignored: (1) Most vehicles were hybrids, but this is not the real-world case, most vehicles are not hybrid. Regeneration probably contributed a significant amount of the energy savings; (2) The 50% savings statement is misleading. It appeared that the 50% only applied to specific maneuvers, not the entire test cycle; and 3) Cyber security was not considered. This would most certainly slow down the connectivity response time.

Reviewer 2:

The reviewer stated that the presentation is very overwhelming with data and information and not clear on outcomes. It is also unclear as to whether the energy savings were for running this simulation on one approach or multiple approaches. The challenge with signal timing is not one direction but balancing the needs across multiple directions.

Reviewer 3:

The reviewer noted that the project has accomplished a significant amount of work in only 2 years. Milestones and products appear to have good relevance to prospective tech transfer candidates. Project completion is especially notable given the design of the control architecture was novel and different than conventional approaches. This team took some technical risks, and they appeared to have paid off.

Reviewer 4:

The reviewer commented that the project team is meeting its milestones as well as delivering the targeted performance. The project approach and technology content were effectively communicated during the project review. The extensive presentation material provided an outstanding level of supporting information. There was sufficient descriptive material to provide the reviewer with a suitable understanding of the technology pathway and the progress to date. It was useful to have this level of project material available ahead of the review. The presentation material clearly shows the program milestones and their status. There is sufficient supporting material to confirm the level of completion.

Reviewer 5:

The reviewer identified very good progress and results in a complicated and multifaceted project.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer stated that that it appears that each partner had a well-defined role.

Reviewer 2:

The reviewer noted that there are many organizations involved in this project. While the team explains each team's competency, it does not clearly describe their actual scope of work and how they interact with each other.

Reviewer 3:

The reviewer commented on great partnerships with industry, government, and academia, with each providing substantive contributions. All the industry partners are excellent potential tech transfer candidates, though it would be very helpful to have an OEM onboard as well.

Reviewer 4:

The reviewer stated that the collaboration is well architected. The balance of university, research institution, automotive suppliers and OEM provides an effective overall project team. Each of the team members are providing significant and useful contribution to the project's progress. The project is well coordinated by the prime. Each organization within the team brings a unique resource and capability to the project. The marriage of these is contributing to the strong progress achieved over the course of the project. An example is the inclusion of drive quality assessment within the project. This is a unique and important addition relative to other system level research activities. It recognizes the importance of system behaviors that will strongly influence technology adoption.

Reviewer 5:

The reviewer noted that many collaborators are from academia and industry. Although it was not very clear what was the actual effort contribution for some of the industry partners, the successful completion of the project goals implies good coordination and collaboration.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer noted that the future work is in line with the original proposal.

Reviewer 2:

The reviewer commented that it is good that future work will be on actuated traffic signals. Since actuated signals make up the vast majority of modern signals, it is unclear why this was not part of the first element of work.

Reviewer 3:

The reviewer stated that previous year reviewers identified surrounding traffic as likely reducing these benefits. It would be very useful to study that in simulation as part of future work. Is the FY 2024 additional system-of-systems analysis with background unconnected traffic actually part of this funded project, or is it proposed as a follow-on?

Reviewer 4:

The reviewer noted that future work is well defined. The list seems very ambitious for the time remaining. It is difficult to judge the likeliness of completing the tasks described in the future work but, based on the strong progress achieved to this point, the project team is likely to complete the stated tasks.

Reviewer 5:

The reviewer commented that the evolution of the concept to include background unconnected traffic is critical to evaluating real-life implementation.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer commented that automation and connectivity are certainly relevant to the VTO objectives. However, a cohort of vehicles is not only unrealistic, but it has also never been heard by the reviewer discussed as a technology to pursue. To the reviewer’s knowledge, no technical roadmaps contain this concept as an avenue to pursue.

Reviewer 2:

The reviewer noted that while the project is relevant to the VTO mission, it is not clear how this would be commercialized or implemented in the real world. It is very highly unlikely that signal systems will be able to receive the level of detailed information on the vehicle that is being proposed here. Perhaps something a bit more practical that incorporates many of the design philosophies here would be more fitting.

Reviewer 3:

The reviewer stated that the project is relevant to VTO EEMS; it has created a new CAV and infrastructure controls architecture, optimized in simulation using statistical and AI techniques, and validated results by track testing. Now what comes next?

Reviewer 4:

The reviewer noted that the project supports the VTO/EEMS goals. The technology is demonstrating both reductions in energy consumption and travel time consistent with an overall improvement in mobility energy productivity. The project deliverables include the development of new tools and provides early-stage technology. It appears the team is effectively sharing its resulting insights. The project’s inclusion of vehicles from multiple OEMs and both light and heavy-duty vehicles provides significant enhancement relative to single OEM or sector specific research. Ultimately, on-road mobility technology will be most effective if it is OEM and sector agnostic.

Reviewer 5:

The reviewer commented that the project has relevance in a world where vehicles will cooperate to form optimized platoons of vehicles. Although, the research findings are very interesting and advance the knowledge and tools, the reviewer is not sure about the real-world implementation potential of the concept as-is.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated a belief that there is a better way to spend $2 million dollars for research in areas that might yield some benefit to the specific objectives within VTO.

Reviewer 2:

The reviewer noted that the project team is very well resourced with many talented team members.

Reviewer 3:

The reviewer commented that resources appear sufficient. The project could have been extended a little longer, with a bit of follow-on funding given the very promising results. The reviewer hopes DOE follows up on this project and discusses what its next steps might be. Are these results generalizable to other locations or after varying the vehicle assumptions? Have there been any tech transfer inquiries from the private sector?

Reviewer 4:

The reviewer noted that, based on the comments from the project lead during the project review, the project could benefit from additional test time on the track to further refine and validate the technology within the project. It seems track availability and cost may limit the outcome that can be achieved from the project.

Reviewer 5:

The reviewer stated that the extensive partnership structure suggests a very good assembly of resources for such a complicated project.

Presentation Number: EEMS106
Presentation Title: Developing an Energy-Conscious Traffic Signal Control System for Optimized Fuel Consumption in Connected Vehicle Environments
Principal Investigator: Mina Sartipi (University of Tennessee)

Presenter

Mina Sartipi, University of Tennessee

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

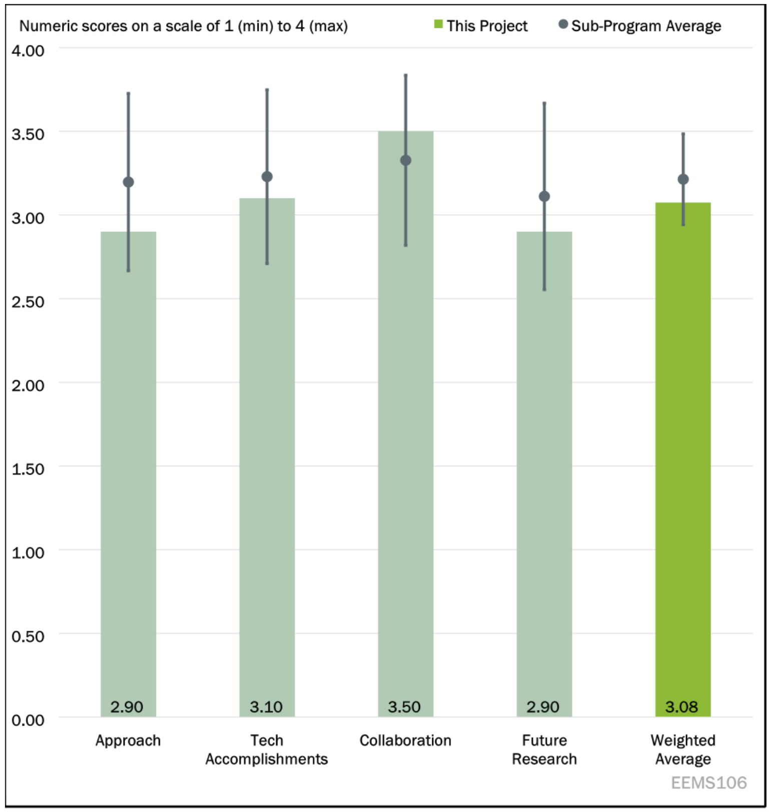

Figure 4-20 - Presentation Number: EEMS106 Presentation Title: Developing an Energy-Conscious Traffic Signal Control System for Optimized Fuel Consumption in Connected Vehicle Environments Principal Investigator: Mina Sartipi (University of Tennessee)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer commented that the project appears to have tight timing to meet project completion of December 2023. It appears some work, like traffic controller experimentation/integration could have been done in parallel instead of waiting for optimized routines to be developed.

Reviewer 2:

The reviewer stated that the overall approach, tools, simulation and use of data are excellent. Approach to Performance index is complex and link to physics and scenario applicability is not clear. Multi-termed equations applicability is uncertain. Two vehicle types are modelled but variants in powertrain (ICE, HEV, Plugin hybrid electric vehicle (PHEV), BEV) on light-duty (LD) vehicles is not clear. Fuel consumption plot is in units of mass; the reviewer would have expected it to be in units of mass/time.

Reviewer 3:

The reviewer noted that in Slide 16, the estimated energy savings in pure simulation is low (less than 3%). With the transition to the real-world testbed and its inevitable additional noise and variability, these savings may likely not be retained. The control architecture of this project is very complicated. It is possible that splitting the four stages (corridor partition, signal coordination, local signal control, multimodal priority) has over-constrained the controller and resulted in local optima for each stage and has hampered overall system improvement. It may be worth sharing the approach and results from each stage to show how they improved upon their respective baselines to see if any of them individually are promising, even if their aggregate effect does not result in significant energy savings. For instance, the global optimization using reinforcement learning showed statistically significant improvements in EcoPI, stop delay, and number of stops. Perhaps it may be better to lean into real world pilot implementations of just these components of the controller rather than the full complicated controller. Is CAVE laboratory really a good place to do integration before field testing? CAVE laboratory's strengths are at a vehicle-level performance (nano-scale), but almost all of the controller development is at the micro/corridor (micro-meso?) traffic level. How would CAVE laboratory help verify micro/corridor level performance? The effort may be better spent elsewhere.

Reviewer 4:

The reviewer stated that based on the material presented at AMR, the project approach seems solid for this stage of the project and the reviewer does not have any concerns about the project team's approach to addressing the identified technical barriers.

Reviewer 5:

The reviewer commented that the use of software-in-the-loop (SIL) studies for planning the field test is an ok practice. It would have been better if the hardware-in-the-loop (HIL) that was performed with only one controller would have used more so networking and communication issues can be tested. The timeline for the field tests is extremely tight; the reviewer does not see much room for second tries if the initial field test encounters difficulties.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer commented that Eco-PI is an interesting metric for global minimization of energy usage. It would be interesting to see a corresponding or modified metric for electrified vehicles due to the differences in idle energy rate and energy recapture. Further comments on the correlation between GHG/energy reduction and Eco-PI would be appreciated. Is it expected that the Eco-PI reduction is much greater? Are the results always directly proportional? It is not clear how the HIL testing/correlation work adds benefit to this project.

Reviewer 2:

The reviewer noted that there are excellent accomplishments in multiple areas. Data collection is especially impressive; real-time digital twin is also a powerful tool. It would be good to see the reporting of results. Only a single data set is given, and this appears to be the best achieved. What is the range of benefits over different scenarios, different traffic densities and flows?

Reviewer 3:

The reviewer identified that attempting a completely new controls approach is always a technical challenge and risk that should be considered as part of a basic research program. This project is also mostly executed per its original proposal. That said, this project could have benefited from more flexibility to deviate from the original FOA proposal. It would have helped if there had been early low-fidelity studies conducted to determine if the total integrated approach (with low fidelity representations of all four stages, not just each individually) looked promising and that would have allowed more agile development to streamline across the four stages. Instead, this project followed a waterfall development schedule in which there was little room to deviate from the original plan. This is as much a reflection of the rigidity of the FOA project management process as about this specific project. For such a complicated control design, the project made significant headway developing all the constituent components of the design.

Reviewer 4:

The reviewer stated that based on the material presented at AMR, they do not have any concerns with the technical progress that has been made against the project plan. The project appears to be on track for timely completion in accordance with the schedule.

Reviewer 5:

The reviewer commented that the presentation did not include a complete project plan. It provided only future milestones, so it is not possible to judge if the project is on time or not.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer noted that university, government, and laboratory collaboration is well done.

Reviewer 2:

The reviewer stated that numerous multiple universities, ORNL and City of Chattanooga all are contributing. The real-world demonstration and determination of impacts will be a significant outcome even if the energy benefits are difficult to determine.

Reviewer 3:

The reviewer commented that it is great that the City of Chattanooga is a research partner and willing to test out these ideas in a real-world testbed. The digital twin may also be invaluable for many other research efforts and is a worthwhile investment. The team appeared to work well together. However, it seems that the laudable desire to collaborate and appeal to each partner's research strengths may also have been what drove this project to create its overly complicated controller. Each partner made substantive contributions toward the project. However, ultimately, the project appeared to need a stronger systems integrator to ensure that all the pieces effectively worked together.

Reviewer 4:

The reviewer stated that based on the material presented at AMR, there appears to be great coordination amongst the project team. Kudos for getting the City of Chattanooga involved as a stakeholder—the reviewer applauds projects that bring local stakeholders with the jurisdiction to implement this type of project in the real world to the table to get feedback about barriers to implementation so that the team can work to address them as the research is being conducted.

Reviewer 5:

The reviewer noted that so far, the collaboration has been very effective and well-coordinated. A lot are depending on the collaboration with the City of Chattanooga but the evidence from the presentation suggests a well-coordinated partnership.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer stated that it may be difficult to complete all of the required work in the remaining time left for the project. Establishing baseline scenarios that allow for representative results, for this type of project, is not trivial. Understanding the error between on-road data and the simulation, even in the baseline scenario can be a challenge, and will need to be adequately understood.

Reviewer 2:

The reviewer noted that the outcome of real-world implementation will be a real success for the project.

Reviewer 3:

The reviewer commented that future research may follow the proposed plan, but given the marginal energy savings of the complete controller demonstrated in pure simulation, this project may want the contract officer to revise scope in order to focus on validating the most promising pieces of EcoPI and/or the four stage process (partitioning, signal coordination, local signal control, multimodal priority) instead of a live testbed running all the pieces together. This could be done on the stage which demonstrated the largest benefit in simulation. That piece of this project might be valuable for other research studies.

Reviewer 4:

The reviewer stated that based on the material presented at AMR, the team has a reasonable approach for future work. It is always challenging to move from simulation to real-world deployment. But the team is doing significant work using hybrid environments (like Digital Twins and SIL/HIL) to help mitigate those risks.

Reviewer 5:

The reviewer noted that the presentation did not elaborate on future research plans beyond the current project scope. Defining as future research the successful completion of the remaining proposed tasks, the schedule is very aggressive and having a lot of risk.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer affirmed that the project meets the objectives of the EEMS subprogram.

Reviewer 2:

The reviewer noted that the project is well-aligned with EEMS including demonstration.

Reviewer 3:

The reviewer stated that the project is relevant to VTO EEMS in its use of AI/ML, game theory, and optimal control theory to improve traffic flow in order to save system-level energy.

Reviewer 4:

The reviewer commented that this project supports VTO/EEMS Strategic Goal 2: Identify and support early-stage R&D to develop innovative technologies that enable energy efficient future mobility systems.

Reviewer 5:

The reviewer noted that optimizing traffic signal control has the potential of great gains in fuel economy and reduction in pollution. The project has a realistic and feasible approach to the problem.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that the resources are sufficient to achieve the milestones.

Reviewer 2:

The reviewer commented that resources are sufficient, and project is meeting milestones and timeline.

Reviewer 3:

The reviewer stated that resources appear sufficient.

Reviewer 4:

The reviewer commented that resources appear sufficient for the project to achieve the stated milestones.

Reviewer 5:

The reviewer noted that all necessary resources seem to be available. Even so the inclusion of an actual vehicle HIL could be considered a bit excessive.

Presentation Number: EEMS107
Presentation Title: Improving network-wide fuel economy and enabling traffic signal optimization using infrastructure and vehicle-based sensing and connectivity
Principal Investigator: Joshua Bittle (University of Alabama)

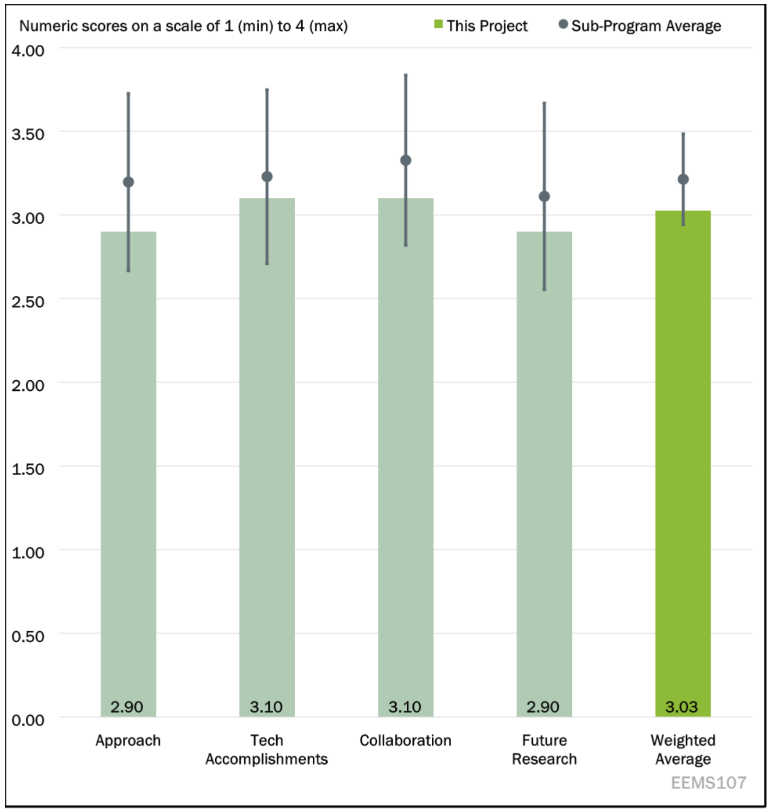

Figure 4-21 - Presentation Number: EEMS107 Presentation Title: Improving network-wide fuel economy and enabling traffic signal optimization using infrastructure and vehicle-based sensing and connectivity Principal Investigator: Joshua Bittle (University of Alabama)

Presenter

Joshua Bittle, University of Alabama

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer stated that the project scope and complexity are both very wide. While there appears to be progress in addressing the technical barriers, it would be easier to understand the contribution of each technological area to the overall efficiency improvement, rather than a final result. For example, are both camera and radar needed? How does the V2X data compare? Are there issues when fusing all data sources together? What is the impact of optimized vehicle control?

Reviewer 2:

The reviewer noted that with respect to estimating energy and emissions saving in future mobility scenarios, this is difficult in mixed traffic scenarios and with only two LD vehicles modelled this would seem to be a difficulty.

Reviewer 3:

The reviewer commented that in Slide 11 the presenter elaborated on the content of the C-V2X/dedicated short range communications (DSRC) submitted publications. One topic described how potentially a single roadside unit (RSU) might be able to broadcast information for multiple intersections. This research would be of great relevance and importance, with FHWA’s recent push for state/local departments of transportation to deploy RSUs at scale in the next few years. According to a DOT spectrum expert, it does not appear that C-V2X

(PC5, or point-to-point) can cover multiple intersections unless it is connected to the broader cellular network communications (Uu), or up/downlink to cell tower. DOT is interested in learning more about the findings from these papers. Simulated results show 10%–15% fuel savings, which is decent though likely to decrease once implemented in the real world (project aimed to reduce fuel use by more than 20% in real world). Three intersections are a rather limited scope to test within. The reviewer suggests considering simulating across a longer corridor, then validating just the three intersections. Of the CDA FOA projects, this team has the most traditional approach and can help establish solid baseline expectations for what current technologies and approaches might achieve when integrated together.

Reviewer 4:

The reviewer stated that based on the material presented at AMR, the project approach seems solid for this stage of the project. However, the reviewer expressed some concerns with the base estimates of fuel consumption. It is documented in the literature that if one wants to use trajectory outputs from microsimulation (i.e., trajectories from microsimulation to estimate fuel consumption), one must calibrate the microsimulation model with trajectory level data—models calibrated with traditional, infrastructure-based data sources (like total volume flow, indicated on Slide 15) are insufficient to have confidence in the trajectories produced by the model. The reviewer cited this report. Getting a proper estimate of current fuel consumption is paramount for assessing if the project successfully reduces fuel consumption by more than 20%.

Reviewer 5:

The reviewer commented that it is difficult to see how the whole framework will work. So far, the presented information has a gap regarding the way the traffic control will be optimized based on vehicle trajectories. Simulation will never produce trajectories that are realistic and based on kinematics that match reality. Car following models do not adhere to physics. For this reason, the reviewer does not see from the presented information how the goal of the feedback loop between optimized traffic control and optimized vehicle trajectories will be bridged.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer stated that project completion given the current timeline may be difficult. There has been a lot of technical progress on individual milestones with regard to data collection and simulation. The synthesis of this data and application to the next milestones involving vehicle integration will be a challenge.

Reviewer 2:

The reviewer identified excellent work on data collection and analysis of vehicles on infrastructure data collection. Sharing data in LiveWire would be an important contribution. It is uncertain about the usability of the distributions as there are numerous factors in the data for car following models.

Reviewer 3:

The reviewer noted that the project is mostly on-schedule, accounting for a six month slip due to lightning strike-damaged hardware. Accomplishments to date are solid and per project management professional (PMP) practices.

Reviewer 4:

The reviewer stated that based on the material presented at AMR, the reviewer does not have any concerns with the technical process that has been made against the project plan. The project appears to be on track for timely completion in accordance with the schedule.

Reviewer 5:

The reviewer commented that, looking at the comments from last year as well as the information presented now, the reviewer doesn't see clear answers have been achieved. Instrumentation and data collection effort accomplished is old news since even in this AMR several projects that have done much more were presented. Regardless, there has been minimal information regarding the field implementation which is a critical part of the go/no-go decision in the project.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer commented that automotive collaboration could be helpful for this project to help develop/enable optimized vehicle controls.

Reviewer 2:

The reviewer stated that collaborations with Alabama Department of Transportation (ADOT) and ORNL are in progress and infrastructure measurements are playing a key role.

Reviewer 3:

The reviewer noted that the University of Alabama (UA) and ORNL teams appear well coordinated, but it is unclear what the role of German Aerospace Center is. Likewise, is the City of Tuscaloosa considered a partner? It is also unclear how long the pilot deployment is supposed to last.

Reviewer 4:

The reviewer stated that based on the material presented at AMR, there appears to be great coordination amongst the project team. What is ADOT's role on the project (they're mentioned on the first slide, but not on Slide 22)? Are they just a data supplier, or an active collaborator? The reviewer suggested getting an infrastructure owner operator involved to help the project team understand and mitigate the challenges associated with deploying this solution in the real world.

Reviewer 5:

The reviewer commented that most of the work is accomplished by UA and specifically the mechanical engineering department. The role of the ORNL effort with the HIL testing is not clear as to why it is necessary for the project. Other collaborations are incidental.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer noted that the proposed future work is valuable, yet still broad. It is recommended to focus on a subset of deliverables for a greater chance of success and completion on time. Actuated and coordinated control vs. fixed-phase coordinated control as a baseline should be re-examined. The research has shown that ACE control provides considerable benefit, at a much lower level of investment and integration effort.

Reviewer 2:

The reviewer commented that important and future research with implementation and demonstration in the corridor will be a significant achievement. The reviewer is not sure how the assessment of, "Ability to impact traffic flow at low connected vehicle penetrations levels will be assessed with two vehicles. It is not clear how the project is targeting, "Powertrain Optimization" per Slide 6 and "engine control module." What engine optimization is being done over the baseline calibration and how is this alternative optimum determined?

Reviewer 3:

The reviewer stated that future work is a reasonable progression from simulation results.

Reviewer 4:

The reviewer commented that based on the material presented at AMR, the team has a reasonable approach for future work. It is always challenging to move from simulation to real world deployment, but it sounds like the project is doing what they can to mitigate the risk through their engagement with the DOT and an OEM.

Reviewer 5:

The reviewer is not fully convinced that what is proposed in terms of future tasks will be feasible given the presented project path. Specifically, it is very unclear how vehicle trajectory optimization will happen in reality. Optimizing a single intersection for a short duration field test is not an exciting accomplishment.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer noted that this program supports the EEMS subprogram objectives.

Reviewer 2:

The reviewer stated that the project meets overall EEMS program objectives with real-world demonstration and impact of traffic optimization and impact on energy (here denoted as fuel economy).

Reviewer 3:

The reviewer commented that the project is relevant to VTO EEMS. With its traditional controls engineering approach, it may usefully serve to set baseline expectations for what integrated connected and automated technologies might accomplish with respect to vehicle- and system-level energy efficiency.

Reviewer 4:

The reviewer commented that this project supports the following VTO EEMS Strategic Goals: Identify and support early-stage R&D to develop innovative technologies that enable energy efficient future mobility systems.

Reviewer 5:

The reviewer noted that the project scope and intentions are very relevant to the VTO subprogram objectives. Novelty of advancements is promising but not great.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that the resources for this project are sufficient.

Reviewer 2:

The reviewer commented that resources seem appropriate but there is a large amount of valuable data that hopefully is used both in this project and can be used by others.

Reviewer 3:

The reviewer noted that resources appear adequate.

Reviewer 4:

The reviewer stated that the resources available for this project appear sufficient to meet the stated milestones.

Reviewer 5:

The reviewer commented that for the budget level the resources are adequate, but others have done more with less. The reviewer hopes the field instrumentation will stay in place to support long term data collection and further research.

Presentation Number: EEMS108
Presentation Title: Co-Optimization of Vehicles and Routes
Principal Investigator: Nick Hertlein (PACCAR)

Presenter

Nick Hertlein, PACCAR

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 80% of reviewers felt that the resources were sufficient, 20% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

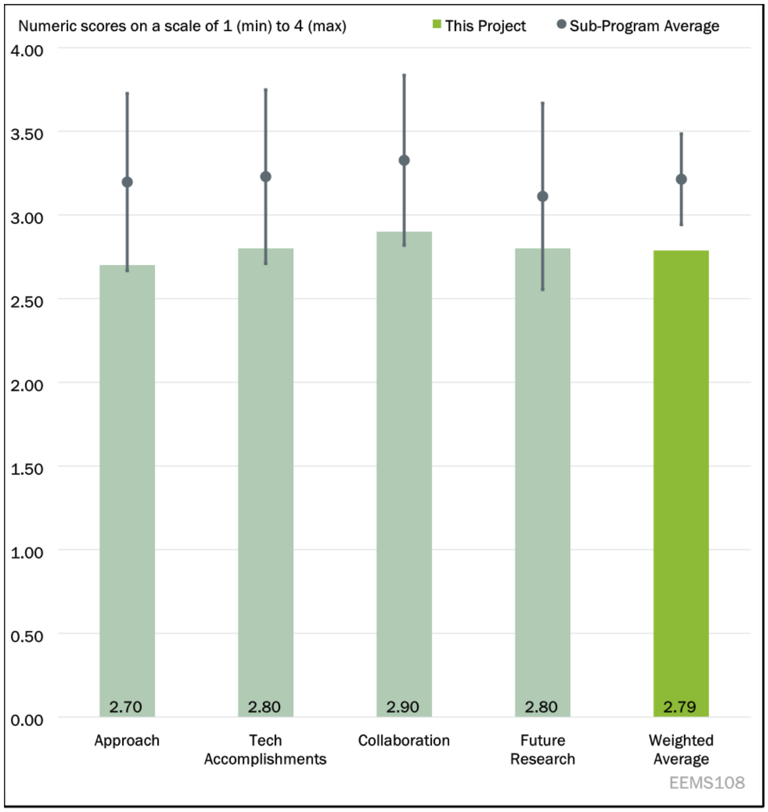

Figure 4-22 - Presentation Number: EEMS108 Presentation Title: Co-Optimization of Vehicles and Routes Principal Investigator: Nick Hertlein (PACCAR)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer noted good use of the eco-routing software. However, the business incentives were not addressed in sufficient detail.

Reviewer 2:

The reviewer stated that the entire project description lacks scope. The program outline Gantt chart lacks a key for color coding. Some of the most important elements of quantifying success is pushed to the last quarter of the project. There appears to be no mechanism for stakeholder feedback, which is essential for buy-in to ensure implementation, adoption and commercialization and sustainment. There are very capable partners with well-defined roles.

Reviewer 3:

The reviewer noted limited impact.

Reviewer 4:

The reviewer was confused by the stated barriers communicated within the project review on Slide 2: Business Incentives for Cloud Providers, OEMs and Fleets; Vehicle to Cloud Architecture Technologies; and Network Bandwidth. Referencing Slide 19, the reviewer reported that the presentation refers the main barrier as, “completing the final analysis and determination of freight efficiency improvement compared to baseline data.” Slide 19 also mentions several technical challenges. The reviewer observed some confusion between technology barriers and project execution barriers and indicated that while there is useful work going on within the project, its alignment with technical barriers seems muddled. The reviewer asserted that the barrier described as, “Business Incentives for Cloud-Providers, OEMs and Fleets,” seems particularly troublesome. If the project is intended to address this barrier, it needs to communicate the project’s approach more effectively. A clearer statement of technical barriers addressed within the project and the alignment with the project deliverables would be helpful from this reviewer’s perspective.

Reviewer 5:

The reviewer commented that the project is aimed at improving fleet energy efficiency by 25% through a multi-pronged approach consisting of four technologies—powertrain optimization, fleet management, eco-routing, and eco-driving. The four technologies are well established and, aside from the use of telematics and cloud platform, it is unclear how connectivity is used to enhance these technologies.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer noted that eco-routing software seemed to perform well, however, assumptions were not made clear—what changes in the powertrain resulted in a 7% improvement? What characteristics did the driver training result in a 5% improvement. Both of these figures are very high. The accomplishments should provide more detail. An assumptions slide would also be helpful.

Reviewer 2:

The reviewer stated that the accomplishments are well described and appear to be on track in comparison to the Gantt chart. The ability to weigh time, cost and a combination is a nice feature.

Reviewer 3:

The reviewer commented that real life traffic data rather than historical data could offer better accuracy in predicting an optimized route.

Reviewer 4:

The reviewer noted that it difficult to judge the progress relative to the project’s scheduled deliverables. There is not an effective overview of the actual milestones and their intended timing. The milestones listed on Slide 5 don’t line up with the tasks on the Program Outline on Slide 4. Project “EEMS105” provided a slide showing the project phases, milestones and their status. It would be best if this project team provided a similar chart.

Reviewer 5:

The reviewer commented that development work seems to have gone through a few iterations and looks to be commensurate with the project timeline. Given that the project is 84% complete, the reviewer would have liked to see more results in the presentation.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer noted good collaboration within the project. However, more information regarding the fleets should have been shared.

Reviewer 2:

The reviewer commented that other than the internal working partners, there is no description of outside stakeholder involvement, from the American Trucking Associations, DOT, AASHTO, National Academies of Science, etc.… There is also no mention of overlap, or coordination with other VTO projects that could be mutually beneficial to the success of meeting project objectives. Driver feedback is also very important.

Reviewer 3:

The reviewer stated that balanced collaboration is evident.

Reviewer 4:

The reviewer noted that the project team includes a useful range of participants. The inclusion of a national laboratory, university, fleet services, and an OEM provides a comprehensive project team. Each of the participating organizations bring a unique resource and capability to the project. Given the description of the project, it appears the level of collaboration is sufficient.

Reviewer 5:

The reviewer commented that the project team consists of team members with necessary and complementary skills. However, the team seems to lack a member with expertise in eco-driving.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer stated that future research is in line with the original project plan and suggested emphasizing model data validation with actual fleet results.

Reviewer 2:

The reviewer commented that stakeholder engagement is instrumental from the onset of the project, with periodic briefings on progress to gage interest and gather information on what potential customers may want so that adjustments can be made where viable. There are good example demonstrations of the integration of systems and example data. This would be of interest to not only the participating fleet, but others as well. Since BEVs are not yet included, it would be appropriate to mention how the location of charging facilities would be incorporated into the route/time calculations for future research. FHWA could be a good source for their plans under the Bipartisan Infrastructure Law (BIL) and/or the Inflation Reduction Act (IRA).

Reviewer 3:

The reviewer noted limited impact.

Reviewer 4:

The reviewer commented that the project team has communicated its purpose for future work. It seems likely the future work will allow the project to achieve its targets.

Reviewer 5:

The reviewer stated that the proposed future work seems logical but lacks specifics on the testing and evaluation plan. It is unclear how the energy efficiency improvements will be attributed to each of the four technologies. Does the project team plan to conduct customer discovery to inform the commercialization of these technologies?

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer noted that this project is very relevant—because most of these tools can be used today—no need to wait for new technology.

Reviewer 2:

The reviewer stated that the project supports VTO subprogram objectives and is relevant in the sense of improving efficiency of fleet management, however some discussion of charging station locations, type and frequency should be included.

Reviewer 3:

The reviewer commented that the project has relevance to an extent.

Reviewer 4:

The reviewer stated that the project supports the VTO/EEMS goals. The project intends to demonstrate reductions in energy consumption related to freight operations and freight travel time which is consistent with the EEMS goal for mobility energy productivity. It is unclear to what extent project data and insights will be shared. It would be useful to communicate the project's approach to sharing consistent with the EEMS goal in this respect.

Reviewer 5:

The reviewer commented that given that freight transportation consumes a large amount of energy, reducing energy consumption and emissions from this sector is important.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that resources utilized on this project seemed in line with the project scope.

Reviewer 2:

The reviewer noted that considering the amount of work yet to be completed and the efforts of incorporating BEVs, additional stakeholder outreach and commercialization, there appears to be a need for additional funding.

Reviewer 3:

The reviewer noted sufficient and multi-skilled resources to meet objectives.

Reviewer 4:

The reviewer stated that resources appear to be consistent with the goals and timing of the project. The project is likely to meet its stated milestones within the project timeline. The reviewer did not note any resource concerns mentioned during the project review.

Reviewer 5:

The reviewer commented that resources should be sufficient.

Presentation Number: EEMS109
Presentation Title: Connected and Learning Based Optimal Freight Management for Efficiency
Principal Investigator: Ali Borhan (Cummins)

Presenter

Ali Borhan, Cummins

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 80% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 20% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

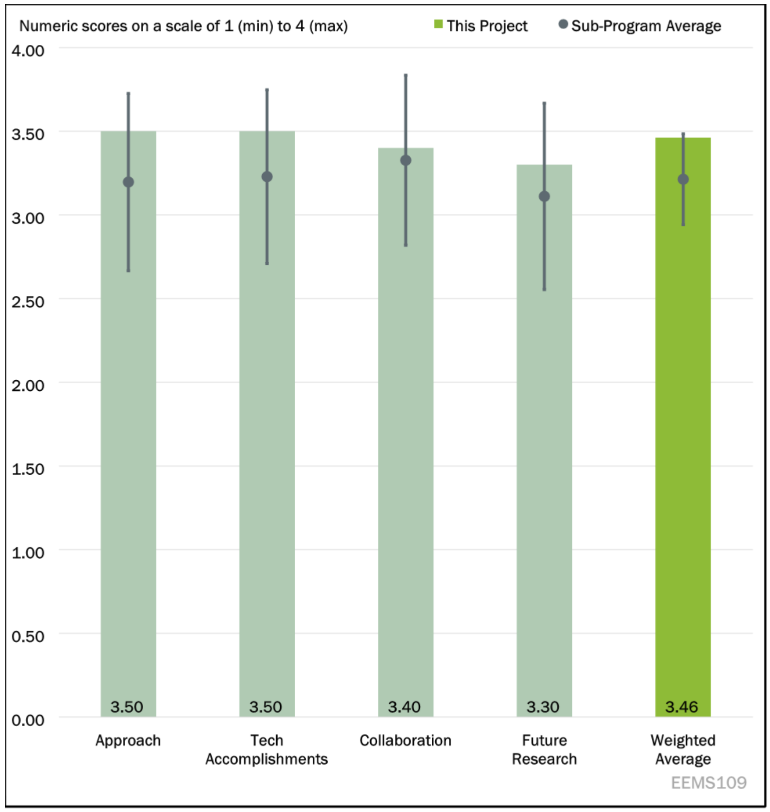

Figure 4-23 - Presentation Number: EEMS109 Presentation Title: Connected and Learning Based Optimal Freight Management for Efficiency Principal Investigator: Ali Borhan (Cummins)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer commented on nicely documented goals and achievements.

Reviewer 2:

The reviewer noted that the project was designed and executed well and had excellent use of real fleet data. More detail could have been shared regarding assumptions like charging station availability, cost of electricity, and cost of hydrogen, among others.

Reviewer 3:

The reviewer noted that the project is ending.

Reviewer 4:

The reviewer stated that the project team clearly identified the barriers it intended to address in the course of the project (optimal decision making for fleet vehicle purchasing and fleet operations for decarbonization). The project content seems well focused to address the barriers described in the project overview. The timeline appears to be aggressive but feasible.

Reviewer 5:

The reviewer commented that the project approach addresses both the investment and operation phases of fleet management, allowing for the optimization of long-term capital planning of emerging technology adoption and short-term day-to-day fleet operation. It is commendable that the project considers well-to-wheel emissions.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer stated that it was an excellent presentation, a lot to learn from.

Reviewer 2:

The reviewer noted that technical accomplishments were demonstrated very well. The graphs on the top right side of Slide 12 are not labeled.

Reviewer 3:

The reviewer commented that the simulation was completed.

Reviewer 4:

The reviewer stated that the project approach and technology content was described very well within the presentation material and was nicely communicated during the project review. There was sufficient descriptive material to provide the reviewer with an effective understanding of the technology plan and the progress relative to the plan. It was useful to have this level project material available ahead of the presentation. There was a lot to cover in a short amount of time. The presentation material clearly shows the program milestones and their status. How these completion dates compare to the project plan is difficult to assess without more detail on the intended project cadence, but the milestones and their timing seem consistent with the high-level timeline.

Reviewer 5:

The reviewer commented that the use of large-scale real-world data provides credibility to the results obtained. The ability to account for real-world payload is unique. While the project team observes similarity between 3-months and 12-months, miles per gallon (MPG) distributions, for the baseline diesel vehicles, indicating stable MPG throughout the year, this may not be true for battery electric vehicles where ambient temperature can have significant effect on range.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer commented that it looks like a lot of people did contribute to the work as planned and appears to be well managed.

Reviewer 2:

The reviewer noted excellent collaboration across the entire project.

Reviewer 3:

The reviewer commented that it is interesting to see the influence from tire rolling resistance but no evaluation of more impactful variables such as drag coefficient or other criteria.

Reviewer 4:

The reviewer stated that the project team includes a useful range of participants. The inclusion of a national laboratory, university, automotive supplier, and an OEM provides a comprehensive project team. Each of the team members is providing significant and useful contribution to the project's progress. For example, the project makes good use of the Argonne POLARIS tool. Also, the inclusion of a dynamic tire model appears to be a useful enhancement relative to other vehicle cycle simulations the reviewer has seen in the past. There are a range of systems in a Class 8 tractor and trailer. The engine and tires are represented within this project team.

Participants from other vehicle system suppliers could certainly bring additional benefits. On the other hand, the team has chosen a manageable range of participants relative to the scope of the project.

Reviewer 5:

The reviewer commented that the project team consists of team members with necessary and complementary skills.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer stated that it seems to be on track.

Reviewer 2:

The reviewer commented that future research is in line with the original project planning.

Reviewer 3:

The reviewer noted validation of simulation results.

Reviewer 4:

The reviewer stated that the slide regarding future work could benefit from some description beyond the milestone headings. It is difficult to interpret the intention and scope behind the headings on the “Proposed Future Research” slide. That said, the project review material was very extensive and it is understandable that some sections may have been light to allow time for other portions of the review material. In any case it seems likely the project team will meet the research targets.

Reviewer 5:

The reviewer commented that proposed future work is thorough and logical.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer noted Electrification and EEMS relevance.

Reviewer 2:

The reviewer stated that a tool like this is important because it can be utilized today—without waiting for the next technology to be developed.

Reviewer 3:

The reviewer commented yes to the defined extent.

Reviewer 4:

The reviewer stated that yes, the project supports the VTO/EEMS goals. The project intends to demonstrate reductions in energy consumption related to freight operations and freight travel time which is consistent with the EEMS goal for mobility energy productivity. The project also supports efficient deployment of freight capital expenditure (CAPEX). The project has provided an effective description of the technical approach and technologies features developed within the activity. It would be good to know the level of data and methodology sharing that the project will provide to the 21CTP community going forward. It appears this project will produce some very useful insight for freight efficiency.

Reviewer 5:

The reviewer noted that given that freight transportation consumes a large amount of energy, reducing energy consumption and emissions from this sector is important.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented that it seems like sufficient fundings were allocated.

Reviewer 2:

The reviewer stated that resources allocated to this project appear to be in line with the scope.

Reviewer 3:

The reviewer commented on the need for stronger coordination and better consideration of other relevant parameters.

Reviewer 4:

The reviewer stated that based on the accomplishments to date, the project appears to be well resourced and effective. The reviewer feels confident the team will achieve the stated milestones within the timeline established for the project.

Reviewer 5:

The reviewer noted that the budget seems high for a mostly modeling project.

Presentation Number: EEMS110
Presentation Title: Human Factors and Technologies Design to Improve User Acceptance of Pooled Rideshare (PR) for Increasing Transportation System Energy Efficiency
Principal Investigator: Yunyi Jia (Clemson University)

Presenter

Yunyi Jia, Clemson University

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

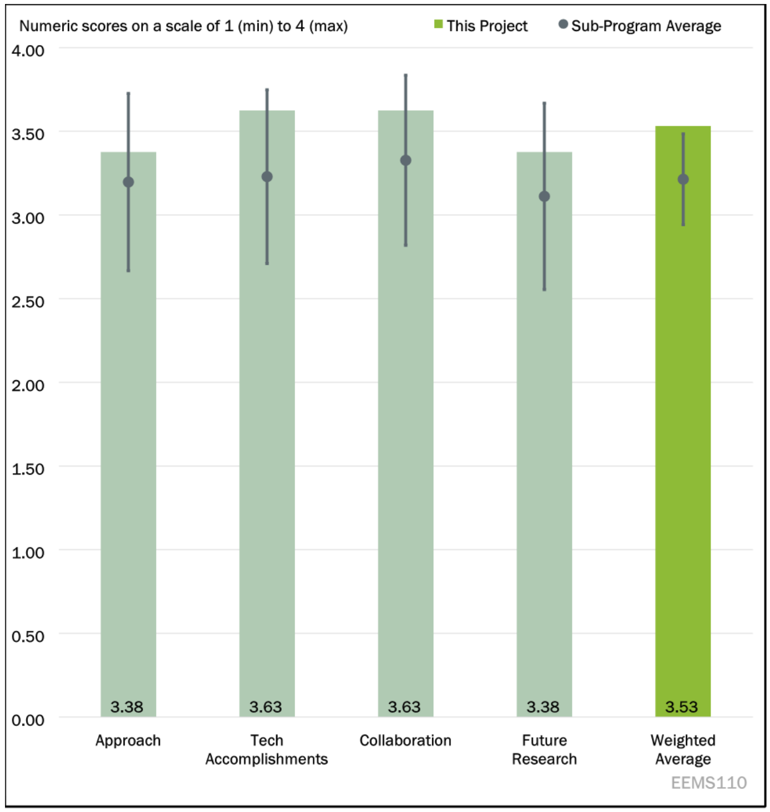

Figure 4-24 - Presentation Number: EEMS110 Presentation Title: Human Factors and Technologies Design to Improve User Acceptance of Pooled Rideshare (PR) for Increasing Transportation System Energy Efficiency Principal Investigator: Yunyi Jia (Clemson University)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer stated that the technical approach for the project involves collecting human factors data to analyze pooled rideshare barriers, develop pooled rideshare acceptance and choice models, and use pooled rideshare acceptance and choice models to assess and validate new human factors guided technology designs. The project is well-designed with successive steps for addressing prescribed barriers involving human factors for accepting pooled rideshare, lack of modeling tools, and validation of new technologies and their impacts on energy use. The researcher provided in-depth coverage of each step in the approach and the respective research objectives.

Reviewer 2:

The reviewer noted that the project addresses a key barrier in the lack of understanding of user-acceptance for pooled rideshare, and more importantly endeavors to design solutions that overcome these barriers and increase pooled rideshare adoption. Pooling rides is a powerful lever for improving the efficiency of the transportation system.

Reviewer 3:

The reviewer commented that the project approach is well designed, spanning original data collection through surveys, factor and choice analyses of the survey data, development of PR choice model from the survey data, and simulation of PR service with and without the PR choice model. The project timeline is reasonable.

Reviewer 4:

The reviewer stated that the research is timely considering that human factors are a driver of modal choices especially carpooling. The reviewer appreciates the approach of integrating human factors into their modeling and approach; this is a critical nexus for understanding the ridesharing landscape. The project is well designed but could have more integration from rideshare providers. The landscape with rideshare like Lyft, Uber, etc. is changing and this project would be strengthened with their engagement especially as the research points to safety and service experience have high impact on decisions around PR. In addition, understanding or gaining insights into future pooled options from companies may help with the projects next steps as well as helping the companies understand influences for pooling in their business models.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer commented that technical progress appears on plan, albeit only at 50% due to nine-month delay. The team has completed two pooled rideshare datasets (factors and choices) as planned; completed analysis and identified human factor barriers; produced the pooled rideshare acceptance model (PRAM) and pooled rideshare choice model (PRCM); initiated the model guided user experience design and optimization; and produced a POLARIS-based simulation for optimizing pooled rideshare optimization strategies and heuristic assignment validation for multiple cities.

Reviewer 2:

The reviewer stated that the project is very logically designed, and the team has made outstanding progress relevant to the project plan. Important information has been gleaned from human factor surveys and studies and choice analysis, and the pooled rideshare choice model has been integrated into POLARIS to evaluate impacts in a medium-sized city. Human factors-based design is underway.

Reviewer 3:

The reviewer noted that the surveys are well designed and produce very useful data, which are then used to develop the PR acceptance and choice models. These models will help PR providers better design PR services that appeal to riders. The project seems to be on track and has produced interesting datasets and results.

Reviewer 4:

The reviewer commented that the project is on track and making progress on the established timeline and milestones.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer commented that the project exhibits excellent internal and external collaborative efforts. Internal collaboration involves diverse partners from academia (Clemson University), a national laboratory (Argonne National Laboratory), industry (J.D. Power, Ford Motor Company, and International Transportation Innovation Center (ITIC)). The research provided a thorough explanation of each team members role and why they were selected for the project. External collaboration involves a variety of other VTO-funded project teams, including EEMS093 POLARIS: Multimodal; EEMS093 POLARIS: Behavior models; EEMS093 POLARIS: Workflow; O'Hare Optimization FOA; and TI104 Rideshare Pilot. The symbiotic relationship has afforded the research with results contributing to the human factor studies of the project, while this project afforded the other projects the human factor results (including the PR models).

Reviewer 2:

The reviewer noted that the collaborative team is impressive, led by a major academic institution partnered with a leading national laboratory, and leading market research firm, a leading automotive company, and an important test facility.

Reviewer 3:

The reviewer stated that the project team consists of team members with necessary and complementary skills. The results from this project are being leveraged in other EEMS projects.

Reviewer 4:

The reviewer commented that, as mentioned above, expanding the partnerships to companies that provide the options for pooling would increase the contributions to the project. More collaboration is needed with these companies especially as this landscape continues to change, especially in light of COVID and changes in transportation patterns. Outreach to PR providers will strengthen the overall outcome and allow the team to be more responsive to the market.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer noted that the researcher did clearly define the future anticipated work for the project. The researcher will be completing the PRAM guided PR vehicle and service designs and validating those designs based on focus group studies and a national survey. The team will also be refining the PR choice model and completing the PR assignment and routing optimization and PR repositioning strategy based on the previous model. Finally, the team will validate PR technologies for improving PR energy savings. These future activities seem reasonable and achievable given they generally work off of previous work and can be accomplished in the remaining time left on the project (1 year+).

Reviewer 2:

The reviewer commented that future work consists of continuing to execute on the existing project plan. The results of the pooled rideshare user experience design will be an important outcome of the project, as will continued model refinement and validation.

Reviewer 3:

The reviewer stated that the proposed future work is logical.

Reviewer 4:

The reviewer commented that the project team has laid out the challenges and framed the next steps and future work. The team should include other partnerships, as mentioned above, the rideshare companies should be considered in future work and evaluations.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer stated that this project focuses on pooled rideshare research for increasing understanding and developing effective modeling tools. The project supports VTO EEMS research initiatives.

Reviewer 2:

The reviewer commented that the project focuses on removing barriers to ride pooling, which is highly relevant to the goals of the EEMS subprogram.

Reviewer 3:

The reviewer noted that increasing usage of pooled rideshare will contribute to reduced vehicle miles traveled and energy consumption from passenger transportation.

Reviewer 4:

The reviewer commented that understanding the intersections of human factors with multimodal transportation options is important especially as the federal government evaluates how mode shift and community design can reduce emissions and save energy and fuel costs.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented that the resources appear sufficient for completing the research and meeting project milestones, although the researcher indicated 50% progress to date with about a year and a half left on the project. The project did receive a no cost extension that was approved due to the delays impacting project data collection.

Reviewer 2:

The reviewer noted that funding resources are sufficient for this project to meet its goals. In context with the overall scope and scale of the project, the outcomes of this project may represent a higher-than-normal return on investment. In other words, while sufficient, the funding resources are modest compared to the potential project results.

Reviewer 3:

The reviewer commented that the resources should be sufficient.

Reviewer 4:

The reviewer stated that the project has the resources to sufficiently meet the milestones and timeline that’s established.

Presentation Number: EEMS111
Presentation Title: Contextual Predictions and Eco Services for Electrified Vehicles
Principal Investigator: Jacopo Guanetti (AV-Connect, Inc.)

Presenter

Jacopo Guanetti, AV-Connect, Inc.

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

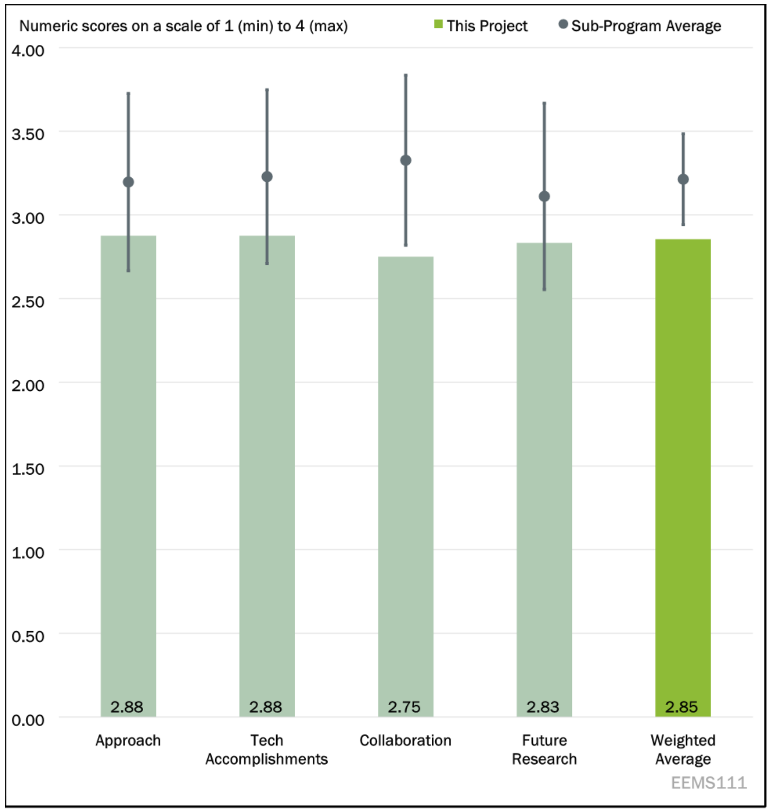

Figure 4-25 - Presentation Number: EEMS111 Presentation Title: Contextual Predictions and Eco Services for Electrified Vehicles Principal Investigator: Jacopo Guanetti (AV-Connect, Inc.)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer commented that it seems that the PI did not present sufficient data convincing the reviewer that the team has made progress planned in this project. It lacks detail of methodology, vehicle information, data sampled, accuracy of model.

Reviewer 2:

The reviewer noted the approach of automated and continuous learning of vehicle, components and driver behaviors. They also combine physics-based and data-driven models to preserve high accuracy in a variety of contexts, capture human and context-dependent factors. Context based segmentation and clustering of data and models. They make predictions of charge usage and charging time, learned from and validated on driving data. This is a good approach to increasing the use of EVs.

Reviewer 3:

The reviewer stated that it is an interesting project, and while the discussion is that this gives more detailed and specific info it still seems very similar to available applications for eco-routing.

Reviewer 4:

The reviewer commented that the overall project provides a solid listing of objectives to increase energy performance and adoption of EVs within commercial fleets and passenger vehicles. Specific objectives for Phase II include the validation of prediction robustness to changes in parameters, and real-world testing of routing and charging planning. The basic approach seems sound. It is to: (1) suggest charging stops to the EV driver for preferred location commerce while minimizing driving time and maintaining minimum journey state of charge (SOC), and (2) assignment of EVs in fleets to specific driving tasks and charging sessions, while maximizing EV utilization, minimizing charging fees, and maintaining minimum SOC. The project presents specific responses to and ways to address identified barriers including inertia, access to data, and computational costs. Furthermore, inherent lower-level challenges are discussed within the approach strategy. The overall project approach offers some unique/novel aspects to help overcome the vexing challenges of barriers to higher EV utilization in commercial fleets and passenger vehicles. Drawbacks of current approaches are discussed.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer stated that as indicated in item 2, it lacks information for reviewer to justify the progress of this project in this year. There is no back-up slide providing further information.

Reviewer 2:

The reviewer commented that the Technical Accomplishments and Progress include streamlined onboarding of transit fleets. Automated daily creation of per-vehicle/per-route predictions, daily creation of driving and charging plans, periodic update of key performance indicators dashboard and daily/weekly creation of prediction accuracy reports. They have also successfully deployed to three fleets.

Reviewer 3:

The reviewer noted that it will help move the EV fleeting into the realm of “Regular Vehicle.”

Reviewer 4:

The reviewer commented that Phase II has focused on robust predictions and EV routing which combines route choice and charge planning. Overall, Phase II has demonstrated solid technical accomplishments and progress. This includes demonstration that high prediction accuracy is robust to the following factors: (1) load variations due to changing occupancy, (2) temperature variations affecting battery charging and auxiliary usage, and (3) driving style variations. Technical accomplishments also include streamlining onboarding of transit fleets and automation of a number of process elements. More importantly, the value of tailored predictions and planning have ostensibly been demonstrated and prospective customers can now envision the entire system. This includes how it may address their challenges of low utilization, high CAPEX and operational expense (OPEX), and difficult operations.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer stated that this team presents the partners of this project in Slide 2 and Slide 14 but did not present any data collected from these partners, which should have been reported. The data collected in this year was not presented in this presentation.

Reviewer 2:

The reviewer commented that Collaboration and Coordination across the project team include, Hyundai America Technical Center, Capital District Transit Authority, Albany, New York, Delaware Transit Corporation, Wilmington, Delaware, Quad Cities Metro LINK, Moline, Illinois, and University of California Berkeley. This group provides vast knowledge in the transit industry. A commercial fleet partner should be included as that industry is much different than mass transit.

Reviewer 3:

The reviewer noted that Industry and Transportation Industry participation is good.

Reviewer 4:

The reviewer commented that the project team appears relatively sound and well rounded. It includes incorporation of validation data from a relatively diverse set of partners. Although, the reviewer would hope there would be available somewhat more commercial fleet data.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer commented that the team proposed to continue its phase II data collection but did not explain the new results to expect. The work proposed for more funding seems will address some of the concerns which should have been done in this project.

Reviewer 2:

The reviewer stated that “Future Research” includes continued data collection for on-road validation of predictions and plans and the final report needs to be produced. Proposed Phase IIB includes cloud infrastructure scaling and scaling of learning and recommendations including support of delivery fleets as well as scaling of deployments and validation (target 100 fleets, 30,000 vehicles).

Reviewer 3:

The reviewer noted that the project is listed as 95% Complete.

Reviewer 4:

The reviewer commented that the primary commercialization to market strategy is to focus on prediction and planning services to commercial fleets. The reviewer agrees with this strategy of targeting the most fertile opportunities, as opposed to a broader strokes approach. Proposed future work under Phase IIB appears to largely focus upon scaling issues which seems to make sense. It focuses upon scaling for cloud infrastructure; learning and recommendations including support for delivery fleets; and deployments and validation (target 100 fleets, 30,000 vehicles). Ultimately, the reviewer guesses the proof will be in the pudding, specifically whether commercial fleets adopt and implement this technology for EV prediction and planning services, and it leads to accelerated EV adoption and utilization.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer stated that this project is relevant to energy efficient mobility system. However, the project did not show any data convincing the reviewer that they have completed the work supporting what this team has claimed.

Reviewer 2:

The reviewer noted that this project has relevance to the VTO by Increase energy performance and adoption of electric vehicles. It also reduces range anxiety.

Reviewer 3:

The reviewer stated that it aligns with reducing Energy use.

Reviewer 4:

The reviewer commented that as indicated, there are a number of barriers to advancing the acceptance of EVs into transportation fleets, especially commercial fleets. Development of accurate and reliable predictions, as well as recommendations for EV routing and charge planning, can significantly help to overcome many of the barriers to EV acceptance. If successful, the project predicts impressive (if somewhat optimistic) energy efficiency reductions of up to 15–20% with EV routing, reduction of charging times and/or charging fees with highly accurate charging time prediction, and an estimate of a 30% increase in fleet utilization leading to lower CAPEX and OPEX for commercial fleets.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer noted that resources may be sufficient, but the reviewer cannot justify it with the information in this presentation.

Reviewer 2:

The reviewer noted that the project is almost complete and should require no additional funding.

Reviewer 3:

The reviewer commented that the project is wrapping up with the $1.3 million listed on page 2.

Reviewer 4:

The reviewer stated that the funding resources are adequate to achieve project objectives and deliverables. The project does not have any cost share.

Presentation Number: EEMS112
Presentation Title: NREL Core Modeling & Decision Support Capabilities (RouteE, FASTSim, OpenPATH, T3CO)
Principal Investigator: Jeff Gonder (National Renewable Energy Laboratory)

Presenter

Jeff Gonder, National Renewable Energy Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

80% of reviewers felt that the project was relevant to current DOE objectives, 20% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 80% of reviewers felt that the resources were sufficient, 20% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

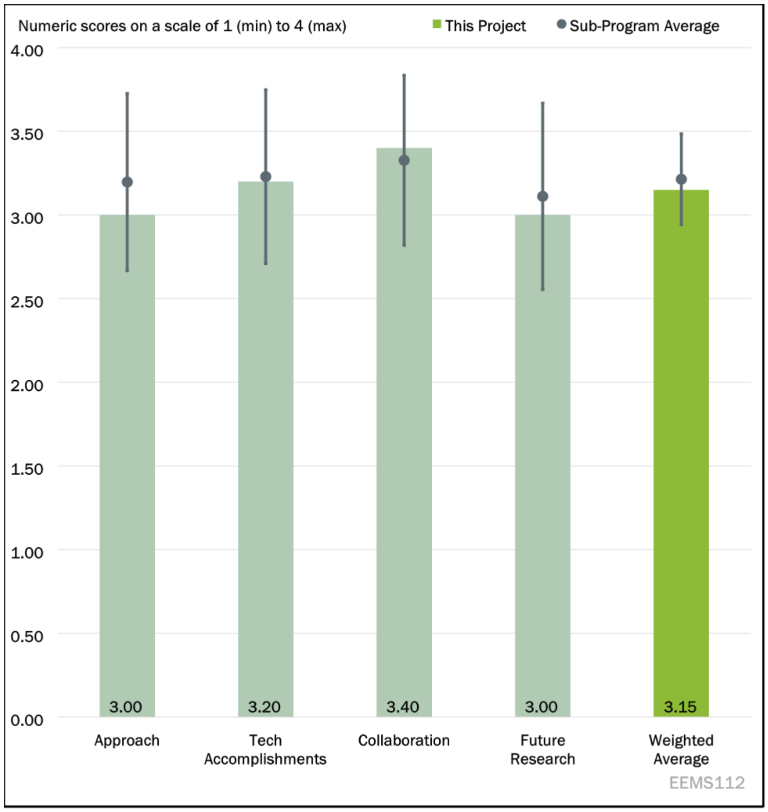

Figure 4-26 - Presentation Number: EEMS112 Presentation Title: NREL Core Modeling & Decision Support Capabilities (RouteE, FASTSim, OpenPATH, T3CO) Principal Investigator: Jeff Gonder (National Renewable Energy Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer stated that this project approach is sound and is comprised of the following elements: (1) Maintain, update/enhance core capabilities (FastSim, RouteE, T3CO) for streamlined vehicle energy + cost modeling and mobility data collection (OpenPATH); (2) Expand representation of emerging technologies (CAVs, etc.); and (3) Create a modeling foundation for laboratory research and for industry collaborations.

Reviewer 2:

The reviewer commented that the top-level concept of the work approach makes sense. The presentation was light on content and details to effectively assess. Fast Sim's focus on most influential factors is good. Work like OpenPATH addresses understood gaps.

Reviewer 3:

The reviewer noted that two of four items are significantly delayed. The overall design of this project is incredibly scattered. There seems to be one nexus point of these applications, but the specific use cases are so incredibly scattered that makes it very difficult to evaluate and complete.

Reviewer 4:

The reviewer stated that the PI and the team are very effective, impressive at dealing with barriers.

Reviewer 5:

The reviewer commented that the approach recognized the shortfalls of democratic process of achieving equity policies and practice and provided alternatives to mitigate the obstruction.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer commented that the project technical accomplishments include the following: (1) FASTSim—validation report, tracking supported publications, thermally sensitive component models, etc.; (2) RouteE—co-optimizing time and energy in Compass, heavy duty truck and transit bus models, validation report, etc.; (3) T3CO—sweep functionality to analyze numerous vehicle/vocation scenarios, payload capacity cost approach.; and (4) Tool Applications—EEMS projects, decarbonization analysis for VTO/DOE, e-bikes, etc.

Reviewer 2:

The reviewer noted that the project appears to have accomplished a significant amount. However, the remaining challenges provide a contradictory picture with a need to improve confidence and ease of use of the work.

Reviewer 3:

The reviewer noted that it seems that the RouteE application has had significant success in being used in other applications that have scale. Little to no information is provided on the outcomes of any of this work, just that its being distributed to others. How many users do each of these partners have? How does one quantify the outcomes?

Reviewer 4:

The reviewer stated that the activities are on track or accomplished as planned, technical progress is as proposed. The reviewer sees improvements from the last year’s review.

Reviewer 5:

The reviewer commented that the OpenPATH app is a useful product supported by ENERGY I-CORPS from DOE. Global positioning system data captured by the app is available from DOE via application, otherwise it is secured for privacy. The other advantage is inviting app users to contribute their data to the study for future enhancement. Color-only differentiation on data plots is problematic for the color-blind.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer commented that the team has demonstrated good collaboration with a variety of stakeholders/partners: Google Maps, PACCAR’s CoVaR project (EEMS108), EPA, Colorado Energy Office, etc.

Reviewer 2:

The reviewer stated that there are clear, numerous end-users. What is not clear is how the end-users contribute to the development or provide feedback.

Reviewer 3:

The reviewer noted that NREL has been successful in distributing this product to many potential users.

Reviewer 4:

The reviewer commented that last year's comments regarding insufficient details of the collaboration and coordination activities have been addressed. This will help increase the overall impact of the project.

Reviewer 5:

The reviewer noted that a wide variety of partners and collaborators, such as cities and states are referenced. Also cited are related EEMS VTO projects. Other countries and US Territories are referenced. FHWA should be considered for data relative to plans under the BIL for charging corridors.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer commented that future work plans include the following: (1) Vehicle model updates for FASTSim; (2) External accessibility of RouteE and T3CO modeling; and (3) Automated, anonymized spatial visualization of OpenPATH data. These are all well-motivated and the work plan is sound.

Reviewer 2:

The reviewer noted that proposed future work is aligned to addressing some user feedback.

Reviewer 3:

The reviewer stated that future work is not well articulated. Many of the items listed are maintenance and operations for the applications. Use of "easy button" multiple times in this presentation is not helpful.

Reviewer 4:

The reviewer commented that the proposed future research is very consistent with the plan, supporting stronger and broader impact of the project.

Reviewer 5:

The reviewer suggested considering reaching out to U.S. Postal Service or United Parcel Service, as this may be useful as a product for them and others.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer stated that the project is aimed at providing modeling tools for optimizing the efficiency of multi-mode transportation, thereby reducing CO_2. This is well-aligned with the VTO subprogram objectives.

Reviewer 2:

The reviewer commented that the different sub projects are aligned with vehicle and overall efficient movement of people and goods.

Reviewer 3:

The reviewer commented that there is no information on quantification of the desired outcomes for the VTO. Items like OpenPath while on the face of it sound great really need a deep dive on how many users it has. It claims to be a solution for a problem around community participation but doesn't show that it actually improves that at all.

Reviewer 4:

The reviewer noted that the relevance of this project to the overall VTO subprogram objectives is very clear; no further comments.

Reviewer 5:

The reviewer stated that relying on in-house data repositories provides long-term control and security. Adding two-wheeled vehicles to the database and functionality—informed policy decisions on expanded bike infrastructure.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that the allocated budget of $1.2 million per year for 3 years is just right for the stated objectives.

Reviewer 2:

The reviewer commented that the budget seems appropriate for the scale of the work. To remain confident that the resources are sufficient vs. excessive, more specific of the scope of future work is necessary for next year's evaluation.

Reviewer 3:

The reviewer noted that many of the items listed as future work are maintenance and operations that are necessary for any commercialized application. The VTO will not be supporting this project in perpetuity and no info is provided on how NREL proposes to sustainably fund this application.

Reviewer 4:

The reviewer commented that the project has sufficient resources to achieve and even exceed its goals.

Reviewer 5:

The reviewer stated that making use of user/partner feedback for future product enhancements contributes to resources, along with an optional open and closed sourced version for different levels of users and licensing opportunities. Relying on in-house data repositories provides long-term control and security.

Presentation Number: EEMS113
Presentation Title: Testing and Evaluation of Curb Management and Integrated Strategies to Catalyze Market Adoption of Electric Vehicles
Principal Investigator: Lauren Harper (Los Angeles Cleantech Incubator)

Presenter

Lauren Harper, Los Angeles Cleantech Incubator

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

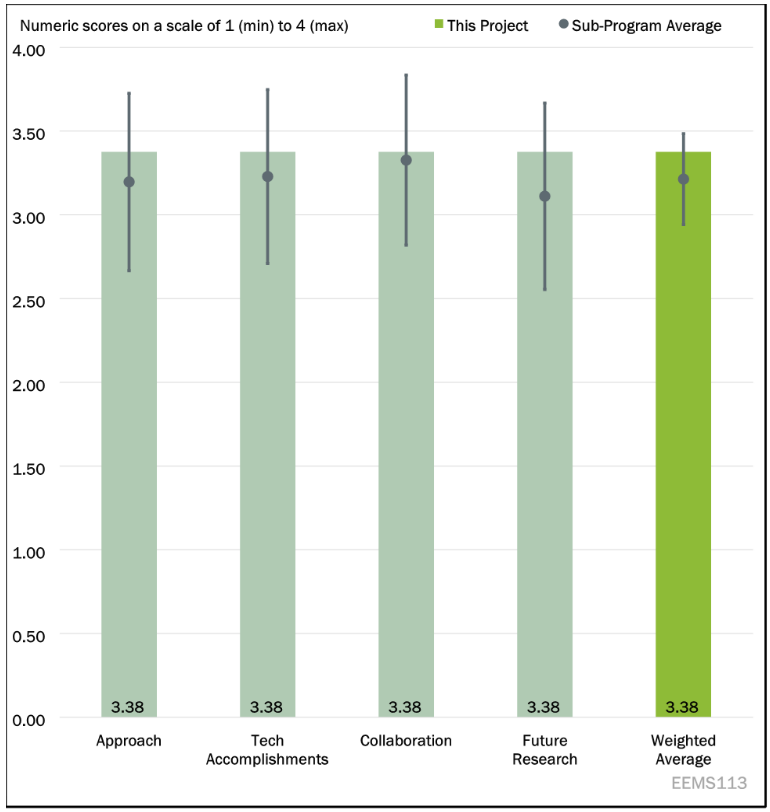

Figure 4-27 - Presentation Number: EEMS113 Presentation Title: Testing and Evaluation of Curb Management and Integrated Strategies to Catalyze Market Adoption of Electric Vehicles Principal Investigator: Lauren Harper (Los Angeles Cleantech Incubator)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer commented that the project is biting off an awful lot but seems well designed to evaluate various approaches to the problems identified. The reviewer thinks the equity issues will need more focused attention, particularly as they will likely surface conflicts among goals. For example, pushing for zero emission gig driving and delivery vehicles in some markets will disadvantage historically underserved populations unless there are additional interventions; effective enforcement may also be more punitive for lower-income drivers of color.

Reviewer 2:

The reviewer noted the approach of disseminating modeling and benchmarking tools to address difficulty managing traffic congestion and enforcement in last mile and rideshare operations. The team will develop and test, simulated and real-world intervention models, to support EV adoption, and create and demonstrate how to use a framework for estimating the energy consumption reduction, cost, and emissions reduction benefits. To compare and evaluate strategies, the team will analyze intervention implications and outcomes, incorporate feedback, adjust modeling, and provide recommendations to cities.

Reviewer 3:

The reviewer stated that the project seems to be well designed. The barriers are significant, such as determining who is involved in a community level oversight committee, how to address any ideology of the committee, and where to install a system like this, for example in urban areas or in suburbia.

Reviewer 4:

The reviewer commented that the project directly addresses barriers related to management and enforcement of policies for curb infrastructure utilization, and specifically targets transportation network company drivers and e-commerce delivery drivers. Additionally, the project considers equity impacts as part of the solution space.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer commented that the project seems to be proceeding well, in general. The metrics feel somewhat arbitrary. The reviewer inquired why target a 5% increase in EV adoption, vs. 7% or 10%, or 100% in California? Is the project pursuing the same increase across all vehicle classes? Is electrifying heavy duty vehicles a higher priority because they otherwise pollute more, or is electrifying gig driving a priority because it does more to support equity? The project would be strengthened by clarifying these points and connecting the dots from metrics to policy interventions.

Reviewer 2:

The reviewer noted progress: Completed Metrics Methodology—NREL, in collaboration with CityFi, finalized the metrics methodology to ensure that the project can support its priority objectives, the curb management goals of local governments and communities and is actively developing a supportive data framework. Verified Dynamic Network Model—Carnagie Melon University verified their dynamic multi-modal curb management simulation package for their MAC-POST, a sophisticated multi modal simulation model. The reviewer noted upgraded hardware and purchase orders submitted by Automotus for better camera vision capabilities.

Reviewer 3:

The reviewer stated that accomplishments seem to be up to date and well done. A good plan going forward.

Reviewer 4:

The reviewer commented that although the project was reported to be only 30% complete, it has made significant progress in its technical milestones. The automated license plate reader technology is a key enabler for the success of the project.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer noted that it seems that the project partners are working together well and are reasonably well balanced. The reviewer would like to see more partners for outreach and dissemination (e.g., local government and planning associations) and more industry partners (e.g., gig driving platforms, delivery services, etc.)

Reviewer 2:

The reviewer commented that the team is strong and has most of the technical avenues covered. However, they do not have any end users involved from the last mile delivery companies or the ride share community. These are important stakeholders as they will have to comply with the regulations. None of the current team has the industrial engineering acumen required that major transportation companies have.

Reviewer 3:

The reviewer stated that the team has all factors engaged with different partners.

Reviewer 4:

The reviewer commented that this is a highly collaborative project, with multiple points of engagement across the national laboratories, technology providers, and local governmental organizations. This level of collaboration is exemplary and will maximize the impact that successful completion of the project will have.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer commented that this project is trying to do a lot of things at once and the reviewer doesn't expect they will all work. But seems some of them likely will. The work on automated license plate reader enforcement and related issues seems particularly helpful.

Reviewer 2:

The reviewer stated that they plan to finalize analysis of the initial project perception survey for pilot participants as well as further refine the metric definitions and identify additional data needs. They will also select locations for loading zones based on siting criteria and scaling up cameras in the cities.

Reviewer 3:

The reviewer noted that the list of future research seems to be complete and noted the following: (1) The privacy versus cameras is a big issue; (2) Equitable is good but reverse equitable also needs to be addressed; and (3) Technically, how is a plate read if next to another parked vehicle?

Reviewer 4:

The reviewer commented that research planned for FY 2023 and FY 2024 is consistent with the original project plan. Scaling up sensing infrastructure, down selecting locations, developing models, and refining metrics are all important parts of the overall effort.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer stated that zero emission delivery zones are a hot topic with local governments, as is curb management, and both deserve EEMS attention.

Reviewer 2:

The reviewer commented that this project supports the priorities of the VTO and clean energy technology to move people and goods by utilizing curb management strategies and interventions to cultivate a roadmap for accelerating electrification, and improved efficiency and accessibility in the transportation sector. The structured, step-by-step roadmap will help other cities achieve their curb management goals, leveraging recommendations, model analysis, stakeholder feedback and city policy from this project.

Reviewer 3:

The reviewer noted that congestion in large cities is an issue, and this research certainly addresses a solution.

Reviewer 4:

The reviewer stated that the project is highly relevant to EEMS subprogram goals. In addition to developing an understanding of curb management issues and solutions to address them, the project is highly focused on on-the-ground deployment and demonstration within the context of environmental justice—priorities for VTO/EEMS.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that there was nothing particular to add here.

Reviewer 2:

The reviewer commented that resources are sufficient; however, they need to add the proper team members for success.

Reviewer 3:

The reviewer believes the funding is sufficient. However, the reviewer does not understand how much data will be collected to be of significance. The project has been expanded to three cities, but how many corridors within the cities are being explored has not been provided. Will seasonal data be extracted? Snow in Pittsburg? Corridors in unequitable areas?

Reviewer 4:

The reviewer stated that given the real-world demonstration component of this project, the funding resources are appropriate. Federal resources are leveraged with significant cost-share as well, demonstrating effective resource management that will support completion of project milestones.

Presentation Number: EEMS114
Presentation Title: Real Twin
Principal Investigator: Yunli Shao (Oak Ridge National Laboratory)

Presenter

Yunli Shao, Oak Ridge National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

67% of reviewers felt that the project was relevant to current DOE objectives, 33% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

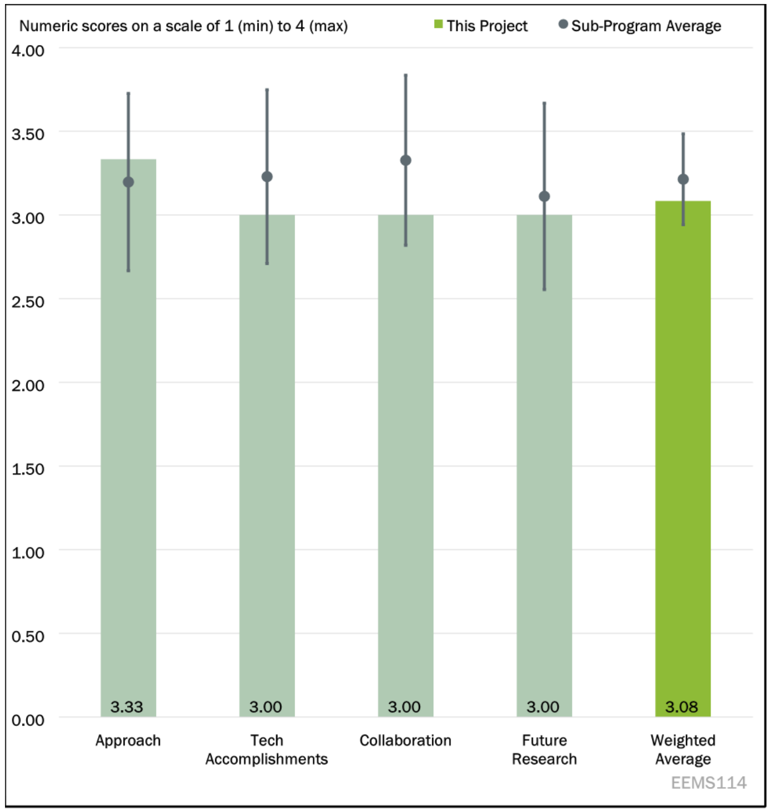

Figure 4-28 - Presentation Number: EEMS114 Presentation Title: Real Twin Principal Investigator: Yunli Shao (Oak Ridge National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer stated that interoperability of microsimulation platforms allows future efforts to proceed in an efficient manner.

Reviewer 2:

The reviewer noted that there was not enough information mentioned during the presentation to justify higher scoring.

Reviewer 3:

The reviewer commented that based on the material presented at AMR, the project approach seems solid for this stage of the project, and the reviewer did not have any concerns about the project team’s approach to addressing the identified technical barriers. The reviewer expressed appreciation for the commitment to developing a model agnostic solution.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer stated that the technical progress outlined in Slides 5 and 7 demonstrated outstanding progress.

Reviewer 2:

The reviewer noted that the project appears to be making adequate process toward the project plan presented on Slide 5 and 7.

Reviewer 3:

The reviewer commented that the rhetoric does not support the objectives of the VTO. There may be someone inside the laboratory that understands what the objectives and impact are, otherwise if you are from a different agency or industry, it is indecipherable. For example, when they use words such as, "A unified, model agnostic scenario generation capability unified, model agnostic scenario generation capability that is equipped with well-defined workflows, integrated tools, and comprehensive metrics that streamline the scenario generation workflows, integrated tools, one might ask themselves, "with what?", "how?" and "why?".

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer stated that the presentation does not appear to reference FHWA traffic research data models and sources at all. There does appear, however, to be some correspondence with other DOT and DOE agencies, as well as industry, academia, and State Highway Agencies. The outcome of these collaborations is not made clear.

Reviewer 2:

The reviewer noted close, appropriate collaboration with other institutions; partners are full participants and well-coordinated.

Reviewer 3:

The reviewer commented that there appears to be sufficient coordination across the project team, as well as with other institutions. The reviewer was pleased with the stakeholder engagement conducted to understand scenario development needs and considerations.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer commented that future research does not appear to build upon or have any anticipation of trends in travel or behavior data. It is a good sign that they cite related EEMS095 and EEMS120 projects.

Reviewer 2:

The reviewer noted that all future work is integral for the success of the project and completed work.

Reviewer 3:

The reviewer stated that on Slide 19, the project team defines their future research for the Real Twin project. On Slide 18, the project team highlights their remaining challenges and barriers. The reviewer has two suggestions for the project team to consider: (1) Re: Network data—As the data "wish list" for scenarios is developed, it would be great to connect observations with the work currently underway to develop the General Network Modeling Specification (https://github.com/zephyr-data-specs/GMNS); (2) Re: Uncertainties w/ CAV and other emerging technology market penetration rates—Many State department of transportations (Texas, Oregon, Maryland, etc.) are starting to use scenario planning for their long range forecasts. It is still not "ground truth" data, but at least we're getting the assumptions from infrastructure owners and operators (which feels more "valid" than us as researchers making these assumptions). How will autocalibration work planned for FY 2024 and FY 2025 be calibrated?

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer commented that the project does not show any tangible evidence that the objectives will be met currently, nor with the plans for the future.

Reviewer 2:

The reviewer noted analysis.

Reviewer 3:

The reviewer stated that this project contributes to the VTO EEMS strategic goals of: (1) Develop new tools, techniques, and core capabilities to understand and identify the most important levers to improve the energy productivity of future integrated mobility systems; (2) Share research insights, and coordinate and collaborate with stakeholders to support energy efficient local and regional transportation systems.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented that the resources are sufficient to carry out the current and future objectives. The reviewer would consider this to be a play on simulation and nothing more.

Reviewer 2:

The reviewer stated that the resources appear sufficient for the project to achieve the stated milestones.

Presentation Number: EEMS115
Presentation Title: Modeling Connected and Automated (CAV) Compute Power
Principal Investigator: Ben Feinberg (Sandia National Laboratories)

Presenter

Ben Feinberg, Sandia National Laboratories

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 25% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

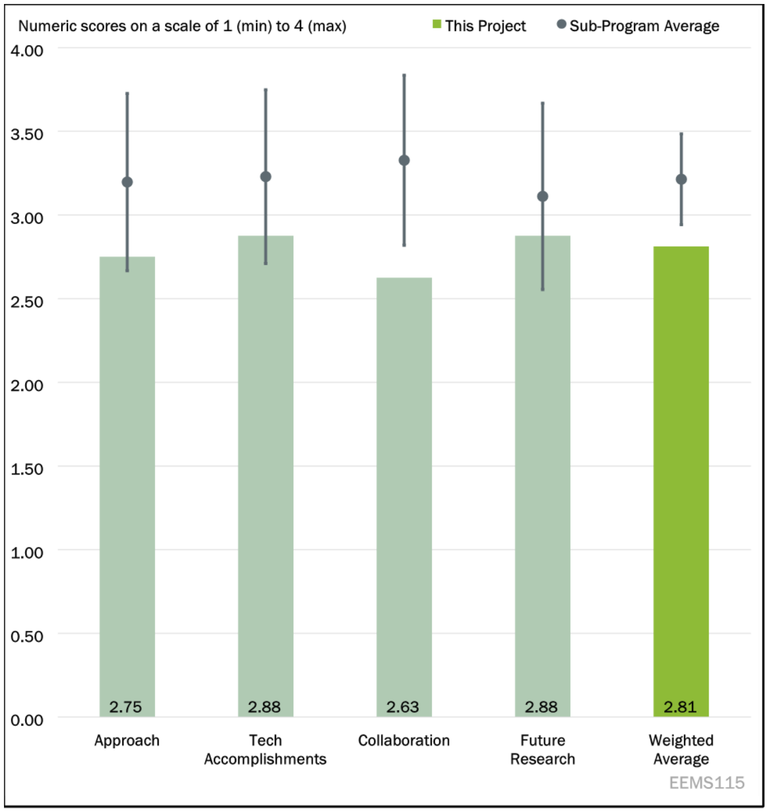

Figure 4-29 - Presentation Number: EEMS115 Presentation Title: Modeling Connected and Automated (CAV) Compute Power Principal Investigator: Ben Feinberg (Sandia National Laboratories)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer noted that with respect to barriers the connection should be clarified. Two are given on Slide 2—inventor current cost/performance and revisit/expand the traditional V-Diagram. It is not clear how these specific barriers are being addressed within this project.

Reviewer 2:

The reviewer commented that the approach in this project is general and fundamental so there are not too many barriers to be addressed. The project, for its stated scope, is well designed and with a reasonable timeline.

Reviewer 3:

The reviewer stated that the program is early in its inception, so the approach seems reasonable.

Reviewer 4:

The reviewer commented that, to be honest, the reviewer doesn’t think the presenter clearly defines the problem and at least the reviewer did not quite understand the whole project clearly.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer stated that this is difficult to assess based upon the information provided.

Reviewer 2:

The reviewer commented that the progress as presented in the AMR meeting does not completely justify a project 83% complete. Still the reviewer believes this to be an issue with the presentation rather than the actual project progress.

Reviewer 3:

The reviewer noted it is early into the program.

Reviewer 4:

The reviewer stated that it is hard to tell if a significant amount of technical progress has been made, based on the presentation. To the reviewer, the slides do not provide enough details to make any judgement.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer commented that it is good to see collaboration with US DRIVE Energy Efficient Advanced Compute (EEAC) working group but unclear what the outcomes of this are. There are very good models developed by other teams on vehicle energy usage that should be referenced and utilized as the baseline per figure on Slide 3. The project team should also consider different class vehicles as it is expected the compute load will not change significantly with the vehicle, but vehicle specific energy consumption varies (W-h/mile) significantly.

Reviewer 2:

The reviewer stated that it is unclear as to the level of effort or active contribution the US DRIVE EEAC Working Group has, other than keeping the PI updated on the subject.

Reviewer 3:

The reviewer commented that it seems as though the project team is only collaborating with US DRIVE EEAC on a monthly basis.

Reviewer 4:

The reviewer noted that maybe this is a relatively small project. There is not much collaborative effort.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer stated that the project is 83% complete and at this point there is only a couple months left. The reviewer is not sure of the output and their impacts. How will the extended modeling framework impact design etc.? Benchmarking is in this year’s work and should include not only consumption but also cooling requirements.

Reviewer 2:

The reviewer commented that the most significant work and proof that the proposed modeling framework is realistic seems to be planned for the future. It is not clear from the presentation how likely it is to achieve its targets.

Reviewer 3:

The reviewer stated that the research depends on the data gathered and the computational experience with the machine. At the lower speeds much more attention is required, but at the higher speeds, response is much more difficult.

Reviewer 4:

The reviewer noted that the future work presented is very limited and rough. More details should be disclosed as this topic is an emerging one and deserves further research.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer stated that Aux electrical, compute, sensing, and cooling loads continue to grow and as vehicles continue to become more efficient reducing these are critically important.

Reviewer 2:

The reviewer commented that relevance is marginal, since the nature of the software and hardware supporting vehicle control is a fast-moving target. It is unclear how the modeling framework will be future proofed.

Reviewer 3:

The reviewer stated that yes, it seems to be relevant for the VTO.

Reviewer 4:

The reviewer noted that it is related to the energy use for CAV due to the increasing computational power.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented that it isn’t clear what the resources being used are so difficult to evaluate.

Reviewer 2:

The reviewer stated that for the scope and budget, resources are sufficient.

Reviewer 3:

The reviewer commented that the work will get done with the resources offered.

Reviewer 4:

The reviewer noted that it is not very sure if the time and partnership resources are enough. It would be great if any OEMs can get involved.

Presentation Number: EEMS116
Presentation Title: High-Quality Perception Data
Principal Investigator: Zach Asher (Western Michigan University)

Presenter

Zach Asher, Western Michigan University

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

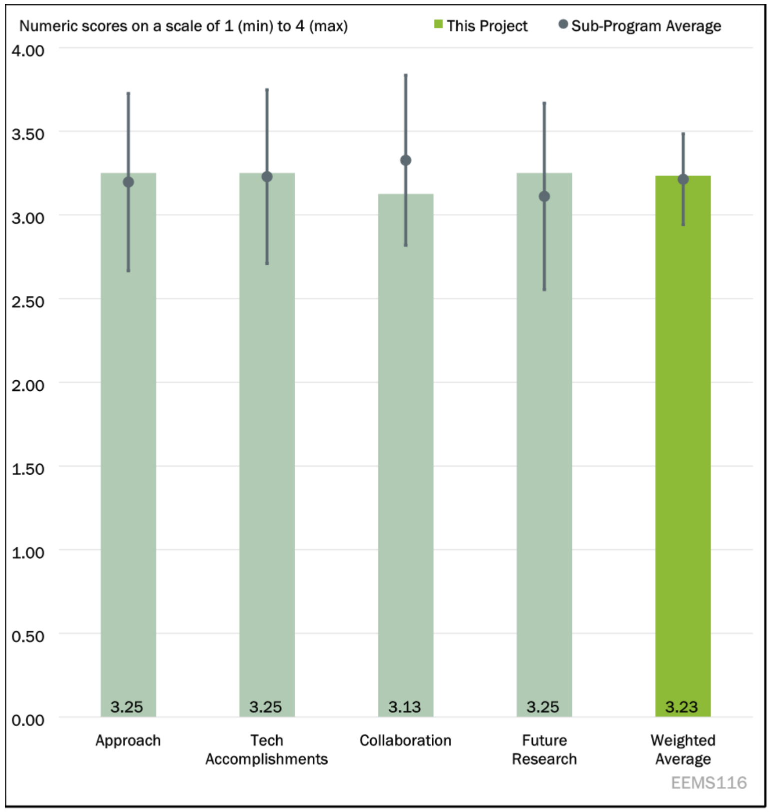

Figure 4-30 - Presentation Number: EEMS116 Presentation Title: High-Quality Perception Data Principal Investigator: Zach Asher (Western Michigan University)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer commented that the project addresses the technical barriers well. Using infrastructure for energy savings (and safety improvements) in the ADAS space is relatively unexplored and presents a very large opportunity for development. The baseline scenario for the “traditional sensor fusion approach” should be further refined moving forward. In this space, automotive OEMs are taking different approaches in sensor usage/fusion and baseline components are continually improving with respect to power consumption.

Reviewer 2:

The reviewer stated that the work appears to be well tracked and performed to address the barriers.

Reviewer 3:

The reviewer noted that the project seems to be progressing well to overcome eventually all planned technical barriers. Even though the PI is confident the project will achieve all its goals, the reviewer has this concern: combining on-board and off-board sensors to improve quality of perception data so that the computing power consumption is significantly reduced might not be achievable in practice, e.g., when not all sensors are providing info, etc. That’s why the reviewer rated the project lower than some others. The reviewer will add related comments below.

Reviewer 4:

The reviewer commented that the concept being explored in this project is very interesting. It is high risk but with potential for high return. The sensor fusion work also adds value to the overall project. The reviewer would encourage the team to quantify the energy usage of the infrastructure-based sensors themselves, and account for it in the estimation and optimization of the overall energy savings for the entire perception system (on-board vehicles and infrastructure).

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer noted that significant progress has been made in the short time since the project started. The project appears to be on track to meet milestones per the plan. Further research/commentary on the disabling of sensors needs to be completed to understand the impact on safety-critical systems and features. Some sensors may not be able to be disabled, or have reduced usage, due to their use in redundant or required safety features. For example, a camera may be used for object detection in addition to lane detection.

Reviewer 2:

The reviewer stated that the technical work appears to be progressing well. Sensors are very important and often overlooked part of “autonomous” driving.

Reviewer 3:

The reviewer rated this higher than above, for the reviewer does appreciate and can relate to complexities of the tech challenges pertaining to real-life experiments. The reviewer encouraged the PI to consider practical challenges when deploying chip-enabled raised pavement markers (CERPMs), retroreflectors, etc. While such units will help greatly in snow and adverse weather conditions, the snowplows can easily damage them unless they are placed inside the road. What about much more complex maintenance, i.e., replacing batteries in such units? US roads are often poorly maintained today, not to mention significantly increased maintenance costs.

Reviewer 4:

The reviewer commented that the sensors have been developed and perception data from these sensors collected. The project seems to be on track and has produced interesting datasets and results.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer stated that collaboration with partners is well done. Working with an automotive OEM or supplier in the future could be beneficial to gain insights on real-world constraints and limitations.

Reviewer 2:

The reviewer commented that they are not sure how much collaboration is being done beyond providing data and/or sensors itself.

Reviewer 3:

The reviewer rated this as “Good”, however the reviewer recommended including (in a no-cost advisory role) somebody from transportation authority/road maintenance company, to guide the project through practical challenges.

Reviewer 4:

The reviewer noted that the project team consists of team members with necessary and complementary skills. It is commendable the team is already working on a spinoff company to commercialize the technology from this project.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer commented that the future research plan appears to be solid. In addition to the energy tradeoff between the new sensors and fusion, it would be good to report out on accuracy and reliability vs. incumbent sensors.

Reviewer 2:

The reviewer stated that future work seems to be progressing well.

Reviewer 3:

The reviewer noted that the project has strong partners that seem to coordinate well. The reviewer doesn’t have concerns about the PI and the team completing the remaining research and achieving the targets.

Reviewer 4:

The reviewer commented that it is unclear how the chassis dynamometer environment would provide realistic computational load requirements for perception. Perhaps, this aspect of the project could be deemphasized while placing more focus on the on-road testing.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer commented that this project supports the EEMS subprogram objectives. In addition, the unique focus on infrastructure integration and development is appreciated. This is an overlooked area for ADAS/ autonomous vehicle (AV) development.

Reviewer 2:

The reviewer noted relevance to Analysis/EEMS.

Reviewer 3:

The reviewer commented that yes, the project is highly relevant to the goals of EEMS, and the reviewer expressed practical concerns above.

Reviewer 4:

The reviewer stated that the outcome of this project could shift the paradigm of how automated vehicles and transportation systems are designed to be more energy efficient.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented that the resources allocated for this project are sufficient.

Reviewer 2:

The reviewer stated that the budget seems to be appropriate to the work which is being performed.

Reviewer 3:

The reviewer commented that the project resources are sufficient to achieve all proposed milestones.

Reviewer 4:

The reviewer noted that resources should be sufficient.

Presentation Number: EEMS117
Presentation Title: Visual-Enhanced Cooperative Traffic Operations (VECTOR) System
Principal Investigator: Cami Qianwen (University of South Florida)

Presenter

Cami Qianwen, University of South Florida

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 33% of reviewers felt that the resources were sufficient, 67% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

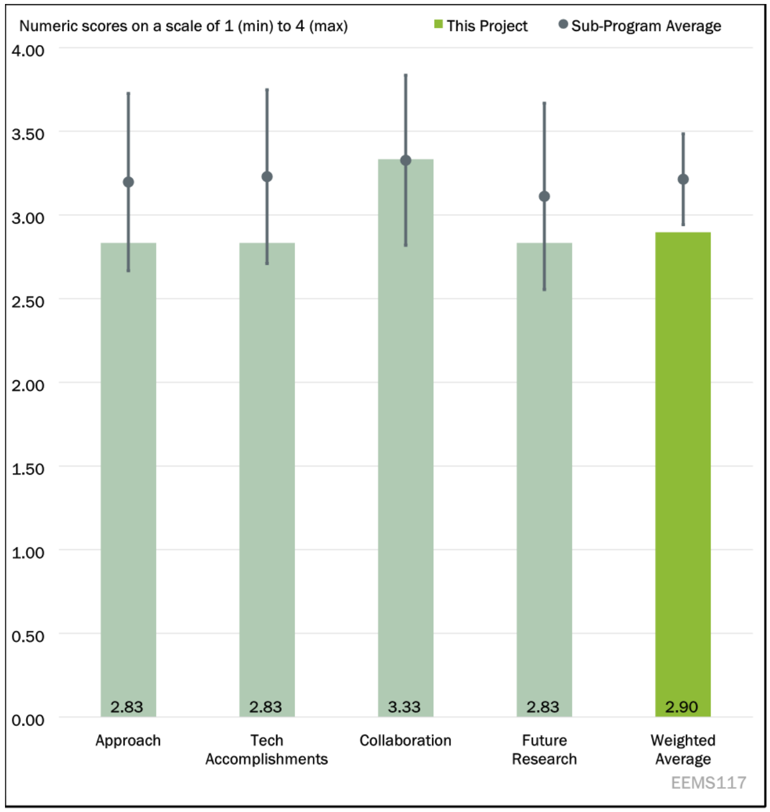

Figure 4-31 - Presentation Number: EEMS117 Presentation Title: Visual-Enhanced Cooperative Traffic Operations (VECTOR) System Principal Investigator: Cami Qianwen (University of South Florida)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer stated that the proposed approach of AI sensing, low-cost communication, cybersecurity, simulation and field testing for this new low-cost architecture for cooperative traffic operations is very well scoped.

Reviewer 2:

The reviewer commented that the project objectives claim large reductions in cost, energy consumption, congestion and crashes. The project plan does not sufficiently outline a roadmap of how these objectives will be met or even measured. The building blocks/enablers being developed may be useful as part of a large CDA system, but the project does not adequately plan their integration in an actionable way.

Reviewer 3:

The reviewer noted that the project approach is logical, combining sensing, communication, computing, and control. The consideration of cybersecurity issues is commendable. Given that the project will take advantage of existing infrastructure and utilize some of the existing sensing and communication technologies, it is unclear how this project would contribute to lower costs and energy consumption for CDA systems. What is the baseline CDA system that the project will compare itself against?

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer commented that technical accomplishments include development of vision-based AI sensing algorithms, light-code communications, and cooperative communications. This is a very good start to an ambitious set of goals.

Reviewer 2:

The reviewer stated that development progress on the individual models appears to be on track. The low-cost signage and communication module appear to be a promising technological area. Further work on the integration and testing plan is required to prove out the benefits of these modules on a system basis.

Reviewer 3:

The reviewer commented that the project is still in an early stage with 25% completion. However, the reviewer would have liked to see more quantitative results in the presentation. For example, what is the performance of the modules shown on Slides 5 and 6?

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer noted that the collaboration and coordination chart show a diverse list of partners and stakeholders including MPO, Bosch, ANL, and University of South Florida, etc. This is an impressive and comprehensive list.

Reviewer 2:

The reviewer stated that there are "many" partners/stakeholders involved in this project. Their exact involvement and commitment to the project is unclear. Further comments on the roles for each contributor would be appreciated.

Reviewer 3:

The reviewer commented that the project team consists of a large number and a diverse group of team members and partners.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer stated that the future research list includes key module development (sensor fusion based CDA data generation algorithm, prototype of AI sensing module, low-cost communication module, etc.) simulation tests, and field tests. This is a good research plan.

Reviewer 2:

The reviewer noted that future work for Phase 2 and Phase 3 needs to be defined. The performance evaluation of the developed modules at a component level is good, but there needs to be a plan to transform their impact on a system level.

Reviewer 3:

The reviewer commented that the proposed future work is logical although more specific details would have been useful. A successful integration of the different modules will be crucial to the success of this project.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer commented that the project is aimed at creating a low-cost architecture for cooperative traffic management and this would lead to efficiencies in transportation and hence support VTO program objectives of CO_2 reduction.

Reviewer 2:

The reviewer noted that the project supports the EEMS subprogram objectives.

Reviewer 3:

The reviewer stated that enabling CDA systems with lower cost and energy consumption will improve mobility and energy efficiency of surface transportation systems.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented yes, the resources are adequate for execution of the stated objectives.

Reviewer 2:

The reviewer stated that to achieve the lofty goals of the project, more resources are likely needed. If the focus was only the development of the four modules, resources would be sufficient. To test at scale and determine system benefits, resources on par with similar projects is required.

Reviewer 3:

The reviewer noted that the budget seems low for a project of this scope and scale.

Presentation Number: EEMS118
Presentation Title: AI-Based Mobility Monitoring System and Analytics Demonstration Pilot
Principal Investigator: Scott Samuelson (University of California, Irvine)

Presenter

Scott Samuelson, University of California, Irvine

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

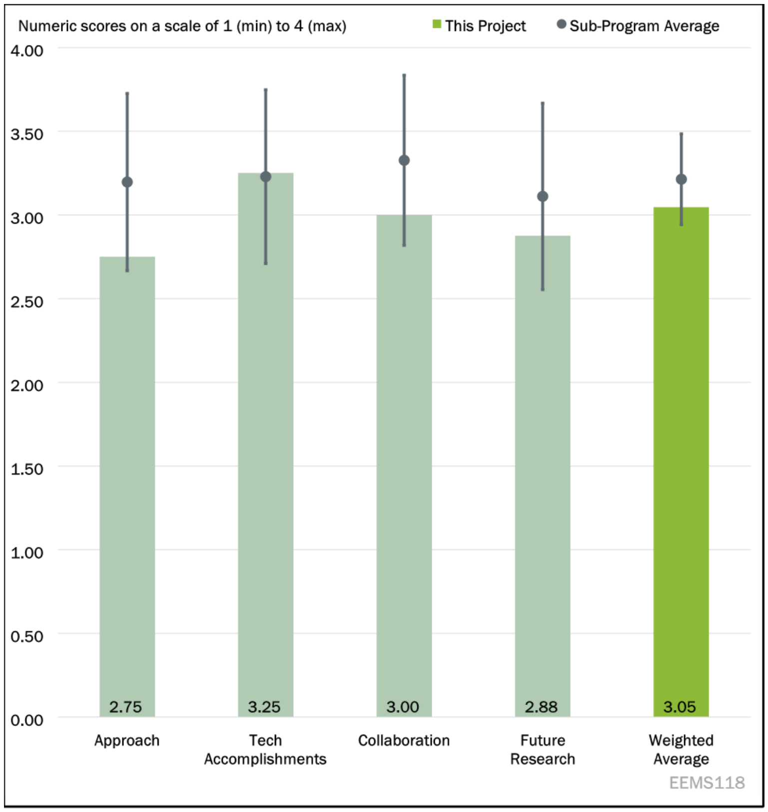

Figure 4-32 - Presentation Number: EEMS118 Presentation Title: AI-Based Mobility Monitoring System and Analytics Demonstration Pilot Principal Investigator: Scott Samuelson (University of California, Irvine)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer commented that many of the milestones are not complete. No information given on why this is the case.

Reviewer 2:

The reviewer noted that the project will likely contribute meaningfully to our understanding of the interaction between and among vehicles and highway-traffic signals. The plan to specifically look at vehicle-to-vehicle communications will be very useful. However, it is not clear that the project is addressing real-world traffic operations issues like pedestrian crossing times at signalized intersections. As the reviewer pointed out during the presentation, it is not clear that benefits from project modeling will accrue when more realistic traffic-signal cycle lengths are implemented. How about responses to traffic incidents? It will be important to understand the components of changes in metrics. How much of any measured benefits from this study's strategies would have accrued from a simple updated timing plan using current technology? Are the new strategies, e.g., driver alerts, likely to be acted upon by diverse population groups?

Reviewer 3:

The reviewer stated that the proposed approach for deploying the sensors and AI-system and testing in XIL is well designed. The timeline may not be very realistic (refer to Question 8).

Reviewer 4:

The reviewer commented that the project is timely and seeks to further investigate as vehicles get smart how do humans interact with alerts that are connected to transportation infrastructure. In addition, the reviewer appreciated that the project team is looking for a solution that can be widely adopted and one that isn't dependent on a specific piece of equipment.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer stated that the simulation results are impressive. More discussion is needed on the existing signal system at the installed intersections (are they actuated? What type of actuation do they have? Do they have adaptive signal control? Etc.). More information is needed on the expected results of the sensors. Much of the simulation results are dependent on the detection distance. What is expected here?

Reviewer 2:

The reviewer noted that the project has progressed, but important questions lie ahead with implementation and additional technical work.

Reviewer 3:

The reviewer stated that the proposed four categories of Controlled Traffic Events is a novel approach.

Reviewer 4:

The reviewer commented that the project team is making progress in alignment with the schedule timeline. The team has demonstrated successful progress with installation of traffic control systems and engagement from city and the university. The team is still installing AI systems, but data has been collected since 2021.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer commented that based on the achievement of expected milestones it seems that project management and coordination has not been efficient.

Reviewer 2:

The reviewer noted that a mix of stakeholders is involved, but involvement of auto users, pedestrians and cyclists, including those of color, would be important in understanding future applicability of this to broader, more diverse communities.

Reviewer 3:

The reviewer stated that the team is qualified, and role of each member and their coordination is clear.

Reviewer 4:

The reviewer commented that the core partners represent the research and governmental agencies and appears to be a strong partnership. Increased engagement from other transportation modes may be helpful including how AI systems can interact with non-motorized forms of transportation.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer commented that the future work described is very high level. Based on the team’s lack of success in the first year, the reviewer would expect this section to be significantly more detailed as to how to make up for lost time.

Reviewer 2:

The reviewer noted that the project’s planned vehicle-to-vehicle research is important. Research into user responsiveness to alerts will be important, as will an understanding of the system-acceptance of both vehicle drivers with communications and those without communications.

Reviewer 3:

The reviewer stated that the proposed work seems to be a heavy lift for the remaining time. Developing a live AI-system and adding V2V data to the AI system seems to be a large challenge for one year.

Reviewer 4:

The reviewer commented that targets are clear, and the future work is likely to achieve the targets. It will be helpful for future work to consider the dynamic nature of streets including pedestrian interactions, bikes, and micro mobility considerations.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer commented that this project is very relevant to the VTO goals and is very practical. This type of project could be scaled by transportation agencies very quickly because it uses many commercially available components.

Reviewer 2:

The reviewer noted that improving vehicle efficiency approaching traffic signals is an important strategy to reduce energy consumption.

Reviewer 3:

The reviewer stated that the project is relevant to EEMS considering the focus on energy efficiency as well as emissions reduction.

Reviewer 4:

The reviewer commented that human factors are a critical component of integration of AI into mobility systems. This research is timely and supports the overall VTO mission.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that no information is given on budget losses given the lack of progress made thus far. If budget has been utilized in a linear fashion rather than based on work achieved this could be rated as insufficient.

Reviewer 2:

The reviewer commented that the project seems to have a generous budget, but the reviewer is concerned that important questions, like user acceptance and the impact of any buses and pedestrian traffic, do not seem to be addressed.

Reviewer 3:

The reviewer stated that the team has access to enough resources to an achieve the goals of the project.

Reviewer 4:

The reviewer noted that resources are sufficient to complete the project and the established milestones.

Presentation Number: EEMS119
Presentation Title: Improved Mobility and Energy Savings Through Optimization of Cooperative Driving Automation (CDA) Application for Signal Controls for Arterial Mixed Traffic Scenarios
Principal Investigator: Xiao-Yun Lu (Lawrence Berkeley National Laboratory)

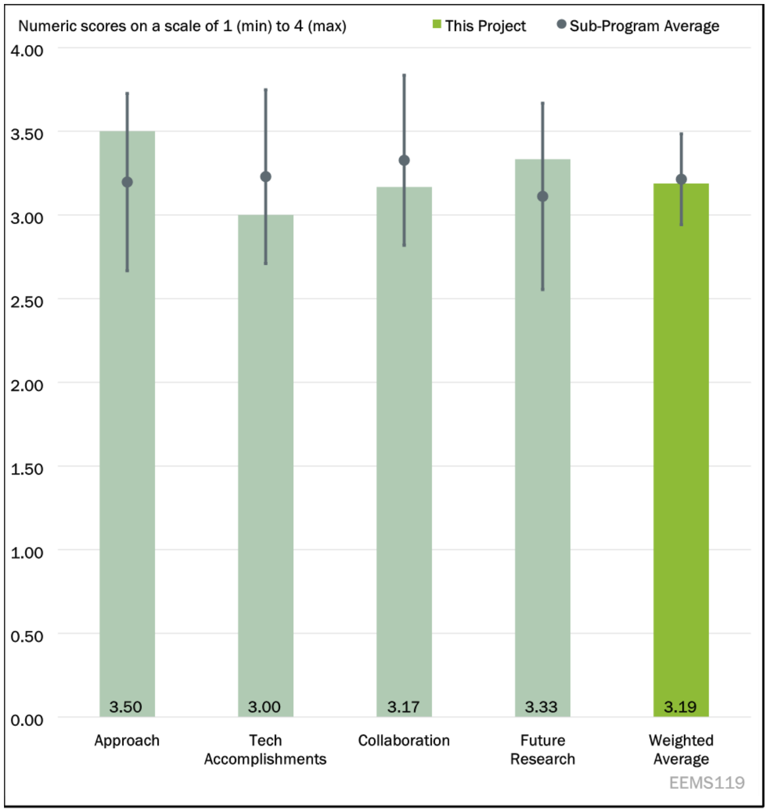

Figure 4-33 - Presentation Number: EEMS119 Presentation Title: Improved Mobility and Energy Savings Through Optimization of Cooperative Driving Automation (CDA) Application for Signal Controls for Arterial Mixed Traffic Scenarios Principal Investigator: Xiao-Yun Lu (Lawrence Berkeley National Laboratory)

Presenter

Xiao-Yun Lu, Lawrence Berkeley National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer commented that on Slides 6 and 7, the reviewer was glad to hear during the presentation that most of the work developing messages is flowing to the relevant SAE committees (though the content still needs refinement prior to real world deployment). With the Federal Communications Commission (FCC) decision, the landscape of V2X is evolving and hardening, so if the project’s communications architectures and messages ignore these hardening constraints, resulting applications will never be viable for real-world deployment. The use of multiple, different vehicle platforms makes the development and testing more realistic and relevant. On Slide 13 regarding the statement, “Not taking into account other vehicles in the front and maneuvers,” this mostly decentralized approach allows an easier pathway to adoption. Industry can implement this with little dependence on external inputs. Benefits may therefore be reaped independent of market penetration rate. On Slide 14 regarding natural CAV strings, it may be worth connecting this project and the Michigan Technological University (MTU) FOA project about cohort size, vehicle order, and timing optimization. The reviewer thinks there could be benefit from common lessons learned and to determine what next steps might be pursued to implement in real world pilot deployments. Summaries of technical takeaways at the bottom of each slide are good as they make the presentation clear.

Reviewer 2:

The reviewer stated that the project appears to be well scoped and provides three vehicles that will be tested as a coordinated group having different powertrains on different infrastructures. The proposed timeline and milestones appear adequate for the project scope and desired outcomes.

Reviewer 3:

The reviewer noted that this is a large scope project aligning needed communications for CAV platooning. It is a good start to getting the plan in place along with model development prior to vehicle testing to begin. The program should also look at making sure that any tool developed is capable of replacing the need for over the road testing.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer commented that the project appears to be on track. Milestone deliverables clearly inform technical requirements for the application under development. Please just make sure this information is published/shared outside DOE and academia.

Reviewer 2:

The reviewer stated that from the presentation it was hard to determine what was accomplished and what was projected to be accomplished in future tasks. Based upon Slides 5, 6 and 7, that clearly label accomplishments for the first year of a multi-year project, the tasks accomplished of C-V2X messaging and literature review are critical for setting the foundation of success for the prime technology development phases of the project.

Reviewer 3:

The reviewer commented that the initial math looks good, but most of the project plan is remaining and is future work.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer stated that the partner list is solid but a bit sparse. ORNL, American Center for Mobility, and California for Advanced Transportation Technology (PATH) are all historical partners. Please consider the potential destination for this work (besides academic publications): USDRIVE, OEMs, SAE, state/local departments of transportation, etc. and identify pathways to engage or potentially tech transfer with them. Is it to inform an SAE standards effort? Is it to encourage licensing of this project’s outcomes? What does success look like for this project in 5 years? 10 years? Consider working with MTU cloud-cohort optimizer team to identify the trends associated with this class of eco-driving application. Are there general high-level requirements regarding communications latency, frequency, bandwidth, mode (dedicated 5.9GHz spectrum versus cellular), types of messages sent (infrastructure to vehicle [I2V] or vehicle to infrastructure [V2I] or both), minimize number of data sets exchanged if possible, and consider centralized versus decentralized control, etc.

Reviewer 2:

The reviewer commented that the project appears to have all sufficient collaborations and partnerships in place to execute the tasks and field demonstration CAVs. Berkeley and ORNL have more than enough resources to support any shortcomings the prime might have (though there doesn’t appear to be any).

Reviewer 3:

The reviewer noted that between all of the laboratories listed (LBNL, ANL, NREL, ORNL, INL) the correct resources are in place for Model Build, Model Use, and Vehicle Test to complete successfully.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer stated that proposed future work is solid—to mature these concepts, the work will need to integrate with mixed traffic and other traffic system management and operations (TSMO) strategies.

Reviewer 2:

The reviewer commented that the proposed future research and tasking is on track for successful integration of C-V2X on multiple platforms and to development and implement the real-time model predictive control (MPC) optimization for CDA.

Reviewer 3:

The reviewer would like see work to prove out that the models are as good as the test to a point where future tests are not needed.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer commented that the project is relevant to VTO EEMS and further matures both vehicle- and infrastructure-based eco-driving algorithms by expanding the number of intersections compared to SMART 1.0 project.

Reviewer 2:

The reviewer stated that this project is the next step of CAV in coordinating multiple vehicles for coherent dynamics to reduce energy and improve mobility, key pillars for DOE VTO.

Reviewer 3:

The reviewer commented that the project aligns with the goal of reducing energy use.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that resources appear sufficient.

Reviewer 2:

The reviewer commented that the team has all the components necessary for successful execution including teaming with ORNL and Berkeley.

Reviewer 3:

The reviewer stated that the $5.6 million listed on Slide 2 should be sufficient to complete the project.

Presentation Number: EEMS120
Presentation Title: A Cooperative Driving Automation (CDA) Framework for Communications
Principal Investigator: Adian Cook (Oak Ridge National Laboratory)

Presenter

Adian Cook, Oak Ridge National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 80% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 20% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

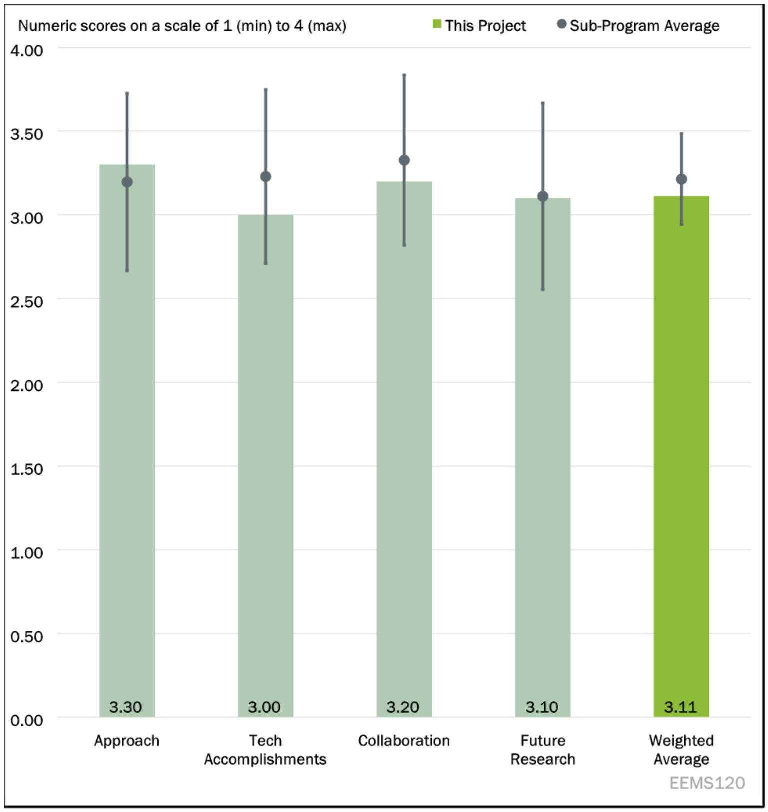

Figure 4-34 - Presentation Number: EEMS120 Presentation Title: A Cooperative Driving Automation (CDA) Framework for Communications Principal Investigator: Adian Cook (Oak Ridge National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer commented that the approach is good and recognizes the high complexity. There are some unanswered questions on how the work will scale up to full on-road universal application for all vehicles. Clarify what work is generating foundational knowledge and what work is aligned to the intended longer term use application where computational complexity and bandwidth are critical factors.

Reviewer 2:

The reviewer stated that work is progressing as planned however work is very front loaded with literature review and simulation.

Reviewer 3:

The reviewer noted that some of these research topics (energy prioritized scenarios, scenario definition) are foundational and therefore will be of broad applicability and interest. AMR slides focus on describing scope of work but neglect to highlight the accomplishments, which is a missed opportunity. The reviewer assumes this is because of AMR time constraints, but even a summary at the end of major takeaways (shown but not necessarily discussed) would be tremendously helpful. On Slide 8, what do ratings 1, 2, 3, and NA represent? What is the 100% scale in each direction supposed to represent? And what were the most energy significant scenarios? Is this summarized in a presentation or report that can be shared? (Task was completed in Oct 2022, so results should presumably be available.) Slide 9 mentions two formats for working group—what working group is this? On Slide 10, are all three applications (platooning, merging, intersection navigation) enabled by this same set of messages and Class C framework? On Slide 12 the project team may want to also learn how others are using event configurable basic safety messages, which allow transmission as needed rather than constant 10Hz. This can reduce spectrum congestion, thereby opening up more potential applications. Also, for energy applications, the project team will probably want to consider non-5.9GHz since that portion of spectrum will likely be dedicated to safety-critical (low latency) applications. Energy applications can often tolerate more latency. On Slide 13, what are "severe road conditions, severe congestion, or severe weather?" On Slide 14, what is total energy savings if Class C adds 6–7% on top of Class A/B?

Reviewer 4:

The reviewer really loves this project from a design and execution perspective. The multiple classes of CDA, the partnering, the leveraging of previous EEMS projects and collaborations is strong and the focus is to show how multiple vehicles of mixed powertrain and OEM origin can work together. The use of XIL on the dynamometer will be a real time and money saver. The reviewer is overall excited for the progression and outcomes of this project and in particular to see it be used to push legislative rules regarding labeling credits/benefits to OEMs for engineering and undertaking connectivity technology.

Reviewer 5:

The reviewer commented that bandwidth to include a large amount of detailed vehicle data has historically not been overcome in similar proposals.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer commented that the project appears to need more time to generate technical accomplishments. It is too early to fully evaluate but appears on track. The thorough review of existing literature is noted and noteworthy. Other areas convey a more work in progress as a new start.

Reviewer 2:

The reviewer stated that it is unclear how work to date is an improvement over state of the art of previous V2X design. There is a statistic on simulated results but little to no info is provided on the key differences that account for this.

Reviewer 3:

The reviewer commented that the project is well-planned and appears to be on schedule. Milestones are very applicable and of interest to many stakeholders; please make them publicly available, so those outside the DOE ecosystem may benefit and learn from work. Please also consider identifying external stakeholders whom the project team may want to brief on this foundational work. It is fantastic to see that the collaborative literature review conducted by the four laboratories has been submitted to Springer for publication—a real team effort.

Reviewer 4:

The reviewer noted that this project is in year one but has made excellent progress on the software and CDA logic side as well as scenario and application.

Reviewer 5:

The reviewer stated that progress appears to be on track with commitments listed on Slide 4. The reviewer appreciates that the review of previous and similar work was thoroughly performed. The signal list looks complete, but the reviewer is concerned about adding additional tracking/communication signals to broadcast. The data shown on Slide 13 is compelling to make the transition to cooperative driving more comfortable to the user/driver.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer stated that collaborators are listed, but need more clarity and details on what the collaboration is, why important, and who is doing what. The slide material suggests much of it is pushing out information (knowledge transfer) vs. deep coordination and collaboration.

Reviewer 2:

The reviewer noted that partner roles are clearly articulated.

Reviewer 3:

The reviewer commented that partnerships with several national laboratories and DOT are excellent. Please also consider if there are any industry, academic, government, or SDO stakeholders the project team may want to engage.

Reviewer 4:

The reviewer noted strong teaming partnership with Berkeley, NREL DOT, Argonne and ORNL. Good to see that there is an effort to seek out overlap and common tool chain.

Reviewer 5:

The reviewer stated that participation and alignment between ANL and ORNL is shown in the presentation and oral review.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer commented that the task steps appear appropriate to work towards the objective, especially the on-road test refinement. More specificity in the plan is warranted.

Reviewer 2:

The reviewer stated that the majority of the work for this project is still in the future especially as it relates to the significant challenges.

Reviewer 3:

The reviewer commented that proposed future work is intriguing. Fault insertion to ensure algorithm robustness is definitely useful. The project team may also want to consider testing with more traffic in either sim or live, as that challenges the tidy assumptions that are often used by algorithms to minimize energy use.

Reviewer 4:

The reviewer noted that what is specific for future research falls within expected approach for such a project. It would be good to see more than just merging scenario, but the reviewer is sure the team will expand to additional scenarios and infrastructures.

Reviewer 5:

The reviewer stated that in laboratory and on road testing is likely needed here and is targeted for future research. The project team should continue work to validate that computer models can replace over the road testing.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer noted that CDA holds the potential to improve overall fleet efficiency.

Reviewer 2:

The reviewer stated that, while it achieves the goals, the improvements from the simulation are relatively marginal. Typically, real work improvements are significantly less than idealized simulations which is a bit troubling here.

Reviewer 3:

The reviewer commented on relevance of driving automation applications to save vehicle- and transportation system-level energy use.

Reviewer 4:

The reviewer stated that this project definitely supports EEMS program goals and objectives and leverages past project outcomes, tools, etc. In the reviewer's opinion, this project has the potential to bring DOT-EPA into working towards inclusion of connectivity credits on certification if approached aggressively and the project demonstrates energy savings accumulated by single vehicles operating with CDA over a meaningful driving cycle.

Reviewer 5:

The reviewer noted that the project fits within the goals to reduce overall energy consumption.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented that a clear breakdown on budget is not available. However, in the absence of expensive resources like physical testing or supercomputing the budget relative to the labor seems high given the information presented.

Reviewer 2:

The reviewer stated that there is still a significant amount of work in the future. The role of FHWA is critical here for knowledge transfer. Understanding how this will work will be very important to make sure this research is of any use.

Reviewer 3:

The reviewer noted that resources appear sufficient.

Reviewer 4:

The reviewer commented that the team has everything they need with super support from other laboratories, partners, etc. It should be a success.

Reviewer 5:

The reviewer stated that the $9 million listed for the program on Slide 2 should be sufficient, even with significant hardware and testing expenditures needed later in the project.

Presentation Number: EEMS121
Presentation Title: Decentralized and Cooperative Traffic Signal Network for Freight Energy Efficiency, Safety, Sustainability, and Public Health
Principal Investigator: Michael Lim (Xtelligent)

Presenter

Michael Lim, Xtelligent

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 25% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

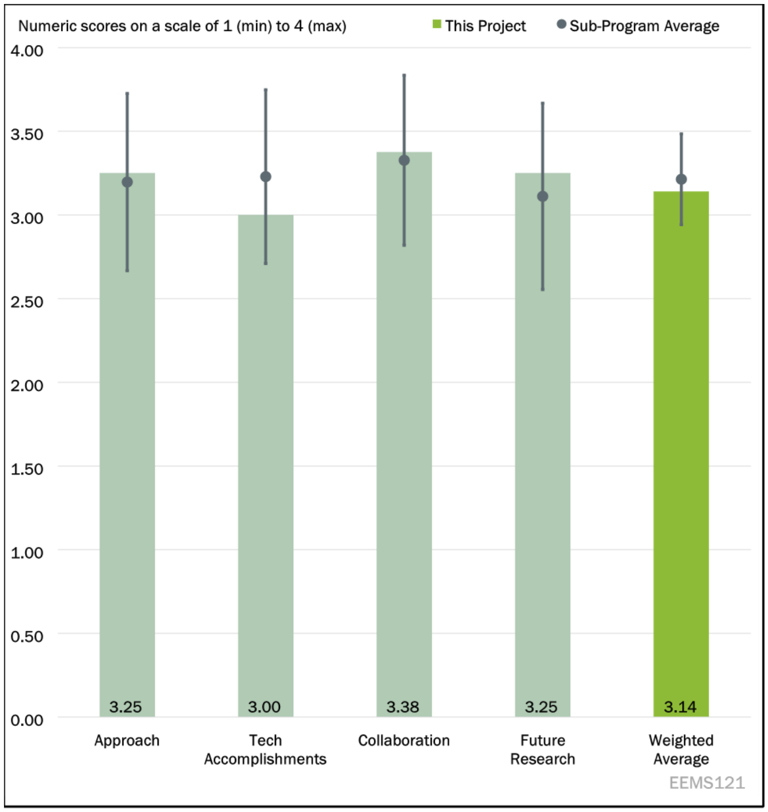

Figure 4-35 - Presentation Number: EEMS121 Presentation Title: Decentralized and Cooperative Traffic Signal Network for Freight Energy Efficiency, Safety, Sustainability, and Public Health Principal Investigator: Michael Lim (Xtelligent)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer commented that the approach proposed for the project is good. It will be good to see how the team will address the challenge with limited amount of CAV data.

Reviewer 2:

The reviewer noted that the objectives for the project are very clearly defined, which is excellent. This includes specific, quantified mobility, energy efficiency, and air quality goals. The approach incorporates three broad elements: (1) Development, system integration, and deployment emphasizing cooperative intelligent transportation systems (C-ITS) operating with high-definition connected vehicles (CVs); (2) Data collection and processing with CV technologies in “living labs”; and (3) Model implementation and energy impact evaluation looking at freight CV technologies and C-ITS technologies under various scenarios. This approach appears reasonable and sound. While the approach is focusing on freight corridors, it is also applicable to the broader light/medium-duty transportation system. Additional strong attributes are that the project takes a software-centric approach which exhibits lower capital expense and will utilize legacy infrastructure hardware systems. Additionally, it is looking not just at corridors, but also at the network level. With regards to defining “success” of the project, the PI indicated the following: (1) technology validation and supply chain throughput gains; and (2) determination that the system can scale. These seem like reasonable broad measures of success.

Reviewer 3:

The reviewer commented that the team has made progress and has completed many of the established milestones. The reviewer also appreciates that the team is looking to wider scale deployment so they are adopting a software approach which can be scaled nationwide. The next steps will be more complicated as the team integrates into real world situations with varying aspects in city environments and varying fleets. The reviewer applauds the team for seeking to address energy efficiency, pollution, and mobility with their project.

Reviewer 4:

The reviewer stated that, frankly, the provided information (presentation) provided no factual evidence that the stated goals or barriers have or can be addressed. If taken on a face value basis, the deployment of instrumentation has happened, and data collection has started. Where, what, and how much are not described.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer noted that the team has reached the milestone of infrastructure being able to receive CV data and vehicles being able to receive signal phasing and timing (SPaT). Details on how this data will be used in the adaptive system nor how the system can work with limited data wasn’t discussed.

Reviewer 2:

The reviewer commented that so far progress was only on practical tasks of hardware deployment and data collection. So far, no innovative progress has been made.

Reviewer 3:

The reviewer stated that the team has made progress, however it does seem that some challenges are being realized in working with varying cities and their rules and protocols as well as the competitive nature of these technologies. The competitive nature of information and data sharing and data security may continue to be a challenge for the project team.

Reviewer 4:

The reviewer commented that the project has demonstrated strong technical accomplishments in its first year and a half. This includes: (1) C-ITS technology deployed in “living labs”; (2) CV data provision pipeline built and tested; (3) backend infrastructure completed; and (4) prototype CV/C-ITS integration with platform has been completed. Critical milestones have been completed including passing the first go/no-go milestone (M1.4) to validate system soundness. The project appears on its way to accomplishing Budget Plan 2 tasks and is roughly on schedule (or maybe slightly lagging).

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer commented that the team has the expertise needed to achieve the goal. The team has shown a collaborative environment.

Reviewer 2:

The reviewer stated that information provided is unclear. Most of the work is accomplished by the PI with support from other partners not justified in the information provided.

Reviewer 3:

The reviewer applauded the partners and corridor that the team chose for this project. Incorporation of the Cities of Long Beach, Fremont and Ontario is remarkable, especially because of the intersections of pollution and impacted communities. In addition, working with OEMs on the solution is key for understanding the dynamics between the vehicle and the roadway networks.

Reviewer 4:

The reviewer commented that the project team is relatively lean but appears effective. The team includes industry, a university, California freight corridor cities, and vehicle manufacturers. In short, a well-rounded team with extensive experience in seemingly all relevant elements including intelligent infrastructure, connected vehicle technologies, R&D, tool development, testing, integration, and demonstration. The team coordinates frequently on a weekly or bi-weekly basis.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer stated that the coming year progress is key to this project, considering the barriers.

Reviewer 2:

The reviewer noted that remaining work seems well planned assuming the unknown C-ITS system promised actually exists. No information is provided. Also, no information is provided on how the system will influence the CAVs.

Reviewer 3:

The reviewer commented that the team is in the early stages of this project, so future work was not discussed in great detail. Also, when asked what success looked like at the end of the presentation the team responded with technical verification and supply chain efficiencies, which is valid, but would that be a direct result of this project? At the next review, the team should think through tangible next steps in research and future work. The integration into MEP could be beneficial to multiple users throughout the nation. The reviewer is looking forward to the next phases of the project and the integration into the MEP tool.

Reviewer 4:

The reviewer noted that the presentation provides a clear, frank discussion of remaining challenges and barriers—which actually is quite refreshing. Briefly, this includes: (1) algorithm development; (2) system testing/integration with legacy systems and competitive concerns; and, (3) data sharing. Reasoned responses and progress are being made to address these issues. This includes new business models/partnerships and recruitment of industry experts to overcome integration challenges and legal approaches to address IP and cybersecurity concerns. Overall, a strong, proactive strategy to tackle these issues.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer stated that this project is relevant to EEMS.

Reviewer 2:

The reviewer noted that conceptually the project is very relevant, but the budget as compared to other much cheaper projects is not justified in the presented information.

Reviewer 3:

The reviewer commented that the project is relevant to VTO’s and EEMS’s work. The reviewer especially appreciates the attention and detail given to impacted communities in their research. Integration of energy efficiency, mobility and environmental justice is critical, and the reviewer appreciates the team’s efforts and attention given to the nexus of these topics.

Reviewer 4:

The reviewer stated that vehicles account for a large percentage of criteria pollutants and GHG emissions, with freight corridors (often in disadvantaged communities) being especially heavy contributors. Successful development, communication, and coordination amongst C-ITS infrastructure and CVs can help significantly in addressing these challenges through improved system efficiency, mobility, and reduction of emissions.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented that the team has sufficient resources to accomplish the goals.

Reviewer 2:

The reviewer noted that for the awarded budget they would expect having some more factual information provided.

Reviewer 3:

The reviewer stated that the project funds appear to be sufficient for the completion of the project.

Reviewer 4:

The reviewer commented that the project appears adequately funded to meet defined objectives and milestones. The project is 50/50 cost shared which is excellent.

Acronyms and Abbreviations – EEMS

Abbreviation	Definition
21CTP	21st Century Truck Partnership
AASHTO	American Association of State Highway and Transportation Officials
ADAS	Advanced driver assistance system
ADOT	Alabama Department of Transportation
AI	Artificial intelligence
AMBER	Advanced Model Based Engineering Resource
AMR	Annual Merit Review
ANL	Argonne National Laboratory
AV	Autonomous vehicle
BEAM CORE	Behavior, Energy, Autonomy, and Mobility Comprehensive Regional Evaluator
BEV	Battery electric vehicle
C-V2X	Cellular-vehicle-to-everything
CAPEX	Capital expenditure
CAV	Connected and automated vehicle
CAVE	Connected and Automated Vehicle Environment
CDA	Cooperative driving automation
CMAP	Chicago Metropolitan Agency for Planning
CO_2	Carbon dioxide
COVID	Coronavirus disease (COVID-19), infectious disease caused by the SARS-CoV-2 virus
CRADA	Cooperative research and development agreement
CTA	Chicago Transit Authority
CV	Connected vehicle
DOE	U.S. Department of Energy
DoX	Design of experiment
DSRC	Dedicated short range communications
DWG	Livewire Data Working Group

Abbreviation	Definition
EEAC	Energy Efficient Advance Compute
EEMS	VTO Energy Efficient Mobility Systems subprogram
EPA	U.S. Environmental Protection Agency
EV	Electric vehicle
eVTOL	Electric vertical takeoff and landing
FAA	Federal Aviation Administration
FCC	Federal Communications Commission
FCEB	Fuel cell electric bus
FHWA	Federal Highway Administration
FOA	Funding opportunity announcement
FRA	Federal Railroad Administration
FSD	Tesla Full Self Driving
GHG	Greenhouse gas
GLOSA	Green light speed advisory
GM	General Motors
GNSS	Global navigation satellite system
HD	Heavy-duty
HEV	Hybrid electric vehicle
HIL	Hardware-in-the-loop
I2V	Infrastructure to vehicle
ICE	Internal combustion engine
INL	Idaho National Laboratory
IP	Internet protocol
IRA	Inflation Reduction Act
ITIC	International Transportation Innovation Center
ITS	Intelligent transportation systems
LBNL	Lawrence Berkeley National Laboratory
LD	Light-duty

Abbreviation	Definition
LDP	Liveware Data Platform
LTE	A wireless data transmission standard
MAC-POST	Mobility Data Analytics Center-Prediction, Optimization, and Simulation toolkit for Transportation Systems
MD	Medium-duty
MDS	Mobility Data Specification
MEP	Mobility energy productivity
MITIE	Micromobility-Integrated Transit and Infrastructure for Efficiency
ML	Machine learning
MPC	Model predictive control
MPG	Miles per gallon
MPO	Metropolitan planning organization
MTU	Michigan Technological University
NCTCOG	North Central Texas Council of Governments
NHTSA	National Highway Traffic Safety Administration
NN	Neural network
NREL	National Renewable Energy Laboratory
NTCIP	National Transportation Communications for Intelligent Transportation System Protocol
OD	Origin-destination
OEM	Original equipment manufacturer
OPEX	Operational expense
ORNL	Oak Ridge National Laboratory
PC5	No base stationary intermediary in V2X LTE-Cellular protocol
PHEV	Plugin hybrid electric vehicle
PI	Principal investigator
PMP	Project management professional
PNNL	Pacific Northwest National Laboratory
PR	Pooled rideshare

Abbreviation	Definition
PRAM	Pooled rideshare acceptance model
PRCM	Pooled rideshare choice model
RDD&D	Research, development, deployment, and demonstration
ROS	Robot operating system
RSU	Single roadside unit
SAE	SAE International, formerly Society of Automotive Engineers
SDO	Standards development organization
SIL	Software-in-the-loop
SMART	Systems and Modeling for Accelerated Research in Transportation
SOC	State of charge
SUMO	Simulation of Urban Mobility
TCO	Total cost of ownership
TI	VTO Technology Integration subprogram
TSDC	Transportation Secure Data Center
TSMO	Traffic system management and operations
TSMS	Transit-Centric Smart Mobility System
UA	University of Alabama
Uu	Cellular network communications
U.S. DRIVE	United States Driving Research and Innovation for Vehicle efficiency and Energy sustainability
V2I	Vehicle-to-infrastructure
V2V	Vehicle-to-vehicle
V2X	Vehicle-to-everything
VECTOR	Visual-Enhanced Cooperative Traffic Operations
VPPG	Virtual and Physical Proving Ground
VTO	Vehicle Technologies Office
XIL	Everything-in-the-loop

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5. Materials Technology

The Vehicle Technologies Office (VTO) supports research, development, demonstration, and deployment (RDD&D) of new, efficient, and clean mobility options that are affordable for all Americans. The office's investments leverage the unique capabilities and world-class expertise of the national laboratory system to develop new innovations in vehicle technologies, including: advanced battery technologies; advanced materials for lighter-weight vehicle structures and better powertrains; energy-efficient mobility technologies and systems (including automated and connected vehicles as well innovations in connected infrastructure for significant systems-level energy efficiency improvement); innovative powertrains to reduce greenhouse gas (GHG) and criteria emissions from hard to decarbonize off-road, maritime, rail, and aviation sectors; and technology integration that helps demonstrate and deploy new technology at the community level. In coordination with the other offices across the Office of Energy Efficiency and Renewable Energy (EERE) and the U.S. Department of Energy (DOE), VTO advances technologies that assure affordable, reliable mobility solutions for people and goods across all economic and social groups; enable and support competitiveness for industry and the economy/workforce; and address local air quality and use of water, land, and domestic resources. The Materials Technology subprogram supports VTO's goals of achieving 100%decarbonization of the transportation sector by 2050. This ambitious goal will be realized through the increased deployment of electric and hydrogen fuel cell vehicles. Materials play an important role in increasing the efficiency of electric vehicles (EVs) through weight reduction and enabling faster charging and sensing technologies. The materials research also contributes to the goal of reducing GHG emissions and recyclability, helping reduce the overall embodied energy of vehicles.

Lightweight Materials activities support national laboratory, academia, and industry-led research in advanced high-strength steels, aluminum (Al) alloys, magnesium (Mg) alloys, carbon fiber composites, and multi-material systems. This includes projects addressing materials and manufacturing challenges spanning from atomic structure to assembly, with an emphasis on establishing and validating predictive modeling tools for materials applicable to light- and heavy-duty vehicles.

Lightweight Materials activities support these VTO program level goals:

- Enable a 25% weight reduction for light-duty vehicles including body, chassis, and interior as compared to a 2020 baseline by 2030, without significantly increasing costs; and
- Develop lightweight alloys with improved strength and fatigue performance for cast and additive manufacturing methods resulting in a 25% weight reduction in powertrain and suspension components by 2030.

Powertrain Materials activities similarly support research to develop higher performance materials needed by electric and hydrogen fuel cell vehicles to increase efficiency and decrease manufacturing cost, helping transition to all electric light duty vehicles by 2035. Weight reduction and electric powertrain system efficiency improvements for heavy-, medium-, and light-duty vehicles are being advanced through this work, addressing challenging components such as inverters, motors, and geartrain. Current priority focus areas for the subprogram include: (1) lightweight alloys with high fatigue strength for suspension components, (2) high temperature materials for lighter brakes, (3) predictive models for powertrain materials, and (4) Integrated Computational Materials Engineering (ICME) tools that use high-performance computing (HPC) capabilities, multi-length scale (atoms to components) material models, and boundary layer resolved thermo-kinetic models.

Project Feedback

In this Annual Merit Review (AMR) activity, each reviewer was asked to respond to a series of questions, involving multiple-choice responses, expository responses where text comments were requested, and numeric score responses (on a scale of 1.0 to 4.0). In the pages that follow, the reviewer responses to each question for each project will be summarized: the multiple choice and numeric score questions will be presented in graph form for each project, and the expository text responses will be summarized in paragraph form for each question. Table 5-1 presents the average numeric score for each question for each project.

Table 5-1 – Project Feedback

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
MAT146	Ultra-Lightweight, Ductile Carbon-Fiber Reinforced Composites	Seokpum Kim (Oak Ridge National Laboratory)	5-9	3.17	3.33	3.17	3.00	3.23
MAT149	Shear Assisted Processing and Extrusion (ShAPE) of Lightweight Alloys for Automotive Components	Scott Whalen (Pacific Northwest National Laboratory)	5-12	3.67	3.67	3.50	2.75	3.53
MAT152	A Hybrid Physics-Based, Data-Driven Approach to Model Damage Accumulation in Corrosion of Polymeric Adhesives	Roozbeh Dargazany (Michigan State University)	5-15	3.25	3.38	3.25	3.00	3.28
MAT159	Cost Effective Lightweight Alloys for Electric Vehicle Propulsion, Fundamental Fatigue and Creep in Advanced Lightweight Alloys	Amit Shyam (Oak Ridge National Laboratory)	5-19	3.13	3.13	3.00	3.13	3.11
MAT160	Cost Effective Lightweight Alloys for Electric Vehicle Propulsion, Hybrid Dispersion Strengthened Al matrix composites for higher efficiency EV powertrains	Mert Efe (Pacific Northwest National Laboratory)	5-23	3.38	3.25	3.38	3.50	3.33
MAT174	Carbon Fiber Technology Facility (CFTF)	Merlin Theodore (Oak Ridge National Laboratory)	5-27	4.00	3.83	2.67	3.67	3.71
MAT196	High Temperature Carbon Fiber Carbonization via Electromagnetic Power	Felix Paulauskas (Oak Ridge National Laboratory)	5-31	3.00	2.50	2.88	2.67	2.69

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
MAT197	Multi-Functional Smart Structures for Smart Vehicles	Patrick Blanchard (Ford Motor Company)	5-35	3.50	3.25	3.25	3.25	3.31
MAT198	Development of Tailored Fiber Placement, Multi-Functional, High-Performance Composite Material Systems for High Volume Manufacture of Structural Battery Enclosure	Venkat Aitharaju (General Motors Company)	5-38	3.50	3.50	3.25	3.25	3.44
MAT199	Ultra-Lightweight Thermoplastic Polymer/ Polymer Fiber Composites for Vehicles (Inter-Lab Project)	Kevin Simmons (Pacific Northwest National Laboratory)	5-41	3.63	3.63	3.63	3.33	3.59
MAT200	Additive Manufacturing for Property Optimization for Automotive Applications	Seokpum Kim (Oak Ridge National Laboratory)	5-46	3.33	3.42	3.25	3.33	3.36
MAT201	Additively Manufactured, Lightweight, Low-Cost Composite Vessels for Compressed Natural Gas Fuel Storage	James Lewicki (Lawrence Livermore National Laboratory)	5-50	3.17	3.33	3.17	3.50	3.29
MAT202	3D Printed Hybrid Composite Materials with Sensing Capability for Advanced Vehicles	Rigoberto Advincula (Oak Ridge National Laboratory)	5-53	2.67	2.83	2.83	2.83	2.79
MAT203	Low-Cost, High-Throughput Carbon Fiber with Large Diameter	Felix Paulauskas (Oak Ridge National Laboratory)	5-57	3.33	2.83	3.33	3.00	3.04
MAT204	New Frontier in Polymer Matrix Composites via Tailored Vitrimer Chemistry	Tomonori Saito (Oak Ridge National Laboratory)	5-61	3.25	3.38	3.50	3.25	3.34
MAT205	Adopting Heavy-Tow Carbon Fiber for Repairable, Stamp-Formed Composites	Amit Naskar (Oak Ridge National Laboratory)	5-65	2.67	2.67	3.00	2.67	2.71

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
MAT206	Soft Smart Tools Using Additive Manufacturing	Jay Gaillard (Savannah River National Laboratory)	5-69	3.00	3.00	3.25	2.88	3.02
MAT207	Multi-Material, Functional Composites with Hierarchical Structures	Christopher Bowland (Oak Ridge National Laboratory)	5-73	3.50	3.25	2.75	3.25	3.25
MAT208	Efficient Synthesis of Kevlar and Other Fibers from Polyethylene Terephthalate (PET) Waste	Daniel Merkel (Pacific Northwest National Laboratory)	5-76	3.25	3.50	2.75	3.25	3.31
MAT209	Bio-based, Inherently Recyclable Epoxy Resins to Enable Facile Carbon-Fiber Reinforced Composites Recycling	Nicholas Rorrer (National Renewable Energy Laboratory)	5-79	3.50	3.50	2.75	3.00	3.34
MAT210	A Novel Manufacturing Process of Lightweight Automotive Seats - Integration of Additive Manufacturing and Reinforced Polymer Composite	Patrick Blanchard (Ford Motor Company)	5-82	3.00	3.00	3.17	3.00	3.02
MAT211	Sustainable Lightweight Intelligent Composites (SLIC) for Next-Generation Vehicles	Masato Mizuta (Newport Sensors, Inc.)	5-85	2.75	3.00	3.00	3.33	2.98
MAT212	Integrated Self-sufficient Structurally Integrated Multifunctional Sensors for Autonomous Vehicles	Amrita Kumar (Acellent Technologies, Sunnyvale)	5-89	2.83	3.00	2.83	2.50	2.88
MAT221	Lightweight and Highly-Efficient Engines Through Al and Si Alloying of Martensitic Materials	Dean Pierce (Oak Ridge National Laboratory)	5-93	3.60	3.60	3.70	3.50	3.60
MAT222	Extending Ultrasonic Welding Techniques to New Material Pairs	Jian Chen (Oak Ridge National Laboratory)	5-97	3.30	3.50	3.20	2.90	3.34

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
MAT223	Extending High-Rate Riveting to New Material Pairs	Kevin Simmons (Pacific Northwest National Laboratory)	5-102	3.25	3.25	2.75	3.25	3.19
MAT224	Solid State Joining of Multi-Material Autobody Parts Toward Industry Readiness	Piyush Upadhyay (Oak Ridge National Laboratory/Pacific Northwest National Laboratory)	5-105	3.50	3.00	3.50	3.33	3.23
MAT225	Surface Modifications for Improved Joining and Corrosion Resistance	Vineet Joshi (Oak Ridge National Laboratory/ Pacific Northwest National Laboratory)	5-108	3.25	3.00	3.25	2.63	3.05
MAT226	Machine Learning for Joint Quality and Control	Keerti Kappagantula (Oak Ridge National Laboratory/ Pacific Northwest National Laboratory)	5-113	3.50	3.50	4.00	3.50	3.56
MAT229	Development of a Novel Magnesium Alloy for Thixomolding of Automotive Components	Govindarajan Muralidharan (Oak Ridge National Laboratory/FCA LLC)	5-115	3.00	3.25	3.25	3.13	3.17
MAT231	Light Metals Core Program Introduction	Glenn Grant (Pacific Northwest National Laboratory)	5-119	3.25	3.50	3.00	2.50	3.25
MAT235	Light Metals Core Program - Thrust 4 - Residual Stress Effects	Ayoub Soulami (Pacific Northwest National Laboratory)	5-121	3.10	3.00	3.10	3.10	3.05
MAT236	Advanced Characterization and Computational Methods	Thomas Watkins (Oak Ridge National Laboratory)	5-125	3.67	3.50	3.17	2.83	3.42
MAT237	Materials, Lubricants, and Cooling for Heavy Duty Electric Vehicles	Jun Qu (Oak Ridge National Laboratory)	5-128	3.38	3.38	3.25	3.38	3.36

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
MAT241	Advanced Processing and Additive Manufacturing for EV Propulsion	Beth Armstrong (Oak Ridge National Laboratory)	5-132	3.50	3.30	2.90	3.20	3.29
MAT242	Advanced Processing and Additive Manufacturing for EV Propulsion, Advanced Ceramics and Processing for Wireless Charging Systems, Novel Ultra High Conductivity Composites for EVs	Tolga Aytug (Oak Ridge National Laboratory)	5-137	3.67	3.67	3.67	3.33	3.63
MAT243	Manufacturing Demonstration of a Large-scale	Srikanth Pilla (Clemson University)	5-140	3.33	3.00	3.33	3.33	3.17
MAT244	LMCP P1A - Sheet Materials with Local Property Variation	Scott Whalen (Pacific Northwest National Laboratory)	5-143	3.75	3.50	3.50	3.25	3.53
MAT245	LMCP P1B - Form-and-Print - AM for Localized Property Enhancement of High-strength Al sheet	Alex Plotkowski (Oak Ridge National Laboratory)	5-145	2.50	2.50	2.17	2.50	2.46
MAT246	LMCP P1C - Local Thermo-mechanical Processing to Address Challenges to Implementing High Strength Al Sheet	Mert Efe (Pacific Northwest National Laboratory /Oak Ridge National Laboratory)	5-148	3.25	3.50	3.50	3.25	3.41
MAT247	LMCP P2A – Solid Phase Processing of Aluminum Castings	Saumyadeep Jana (Pacific Northwest National Laboratory /Oak Ridge National Laboratory)	5-150	3.00	3.25	2.50	3.00	3.06
MAT248	LMCP P2B – High Intensity Thermal Treatment	Aashish Rohatgi (Pacific Northwest National Laboratory)	5-152	3.67	3.33	3.17	3.50	3.42
MAT249	LMCP P2C – Cast-and-Print – AM for Localized Property Enhancement of Al castings	Alex Plotkowski (Oak Ridge National Laboratory)	5-155	2.75	2.75	2.38	2.50	2.67

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
MAT250	LMCP P3A - Cast Magnesium Local Corrosion Mitigation	Vineet Joshi (Pacific Northwest National Laboratory /Oak Ridge National Laboratory)	5-159	3.40	3.20	2.90	3.00	3.19
MAT251	LMCP P3B - Thermo-mechanical Property Modification of Mg Castings	Mageshwari Komarasamy (Pacific Northwest National Laboratory)	5-163	3.00	3.17	2.83	3.00	3.06
MAT252	LMCP - Thrust 4 - Materials Lifecycle	Jeff Spangenberger (Argonne National Laboratory)	5-166	3.00	2.88	2.63	2.88	2.88
MAT254	Conductive Lightweight Hybrid Polymer Composites from Recycled Carbon Fibers	Yinghua Jin (RockyTech, Ltd.)	5-169	3.50	3.33	3.50	3.17	3.38
MAT256	Game Changing Resin/Coating/ Adhesive Technology for Lightweight Affordable Composites	Scott Lewit (Structural Composites, Inc.)	5-172	2.50	2.25	3.25	1.50	2.34
MAT257	Changing the Design Rules of Rubber to Create Lighter Weight, More Fuel Efficient Tires	Kurt Swogger (Molecular Rebar Design, LLC)	5-174	3.50	3.33	3.33	3.33	3.38
MAT259	Green Composites Fabricated from Bacteria Retted Bast Fiber and PLA for light weight vehicle Components	Lee Smith (Z&S Tech, LLC)	5-177	3.00	3.13	2.25	2.50	2.91
MAT260	Green Composites from Carbonated Bio-based Oils and Recycled Nanofibers	Jesse Kelly (Luna Labs, USA)	5-181	2.67	3.00	3.00	3.25	2.95
MAT261	Multiscale Bioinspired Enhancement of Natural-Fiber Composites For Green Vehicles	Lorenzo Mencattelli (Helicoid Industries, Inc.)	5-184	3.17	3.17	3.33	3.25	3.20
MAT262	Sustainable Automotive Composites Using Surface-Modified Cellulose Fibers	Girish Srinivas (TDA Research, Inc.)	5-187	2.67	2.50	3.33	3.00	2.71

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
MAT263	Green Polybenzoxazine/Natural Fiber Composites for Transportation	Christopher Scott (Material Answers, LLC)	5-190	3.17	3.00	3.33	3.00	3.08
MAT264	Green composites for future vehicles, Vitrimer Matrix + natural and recycled fiber composite Materials for high performance, repairable, recyclable, and bio-sourced automotive components	Philip Taynton (Mallinda, Inc.)	5-194	3.00	2.75	2.75	2.75	2.81
Overall Average				**3.22**	**3.18**	**3.11**	**3.05**	**3.17**

Presentation Number: MAT146
Presentation Title: Ultra-Lightweight, Ductile Carbon-Fiber Reinforced Composites
Principal Investigator: Seokpum Kim (Oak Ridge National Laboratory)

Presenter

Seokpum Kim, Oak Ridge National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

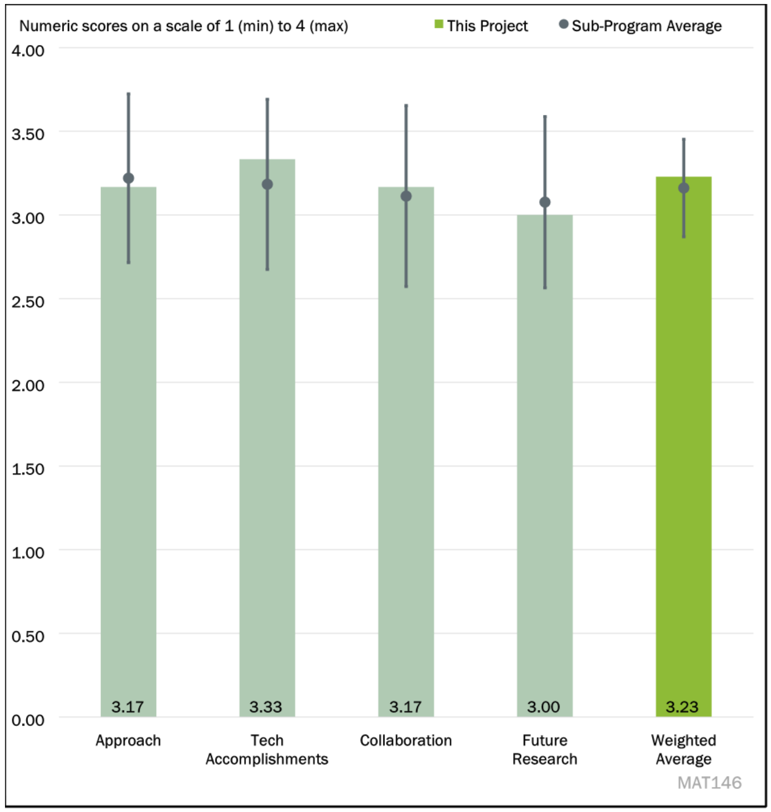

Figure 5-28 - Presentation Number: MAT146 Presentation Title: Ultra-Lightweight, Ductile Carbon-Fiber Reinforced Composites Principal Investigator: Seokpum Kim (Oak Ridge National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer observed that the project showed significant progress and was aggressive towards scaling the printed objects. The results are very interesting and will contribute good science and engineering. The project showed great progress on printer and part design optimization, according to the reviewer.

Reviewer 2:

The project seems to this reviewer to have been carried out at the right phase, and the milestones reached in a timely and convincing manner with the presented results. The reviewer asks: (1) Whether the effort on the three-dimensional (3D) printer speed of printing has been an important factor in meeting the number of samples, i.e., how fast samples can be printed. The reviewer comments that, other than the print method, related stereolithography and digital light processing [DLP] methods are slow. (2) What is the timeline for the testing with various compositions including how fast is the procedure for preparing the formulation?

Reviewer 3:

This reviewer found that the team has made inroads into some of the criticisms leveled last year, specifically in regard to throughput and cost but that much work is yet needed to completely address these issues in the future. An explanation is needed for the technical progress that has been made compared to the project plan.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer commented that the technical progress was carefully executed leading to some good results. The reviewer feels that it would be good to see the baseline performance metrics for the vehicle bumper to evaluate how close the lightweight print design meets those metrics.

Reviewer 2:

This reviewer applauds the vehicle bumper with graded architecture as an excellent demonstration part for this technology.

Reviewer 3:

This reviewer calls for an explanation of (1) how specific geometries or nature-inspired structures track with the simulation effort on the strength to be achieved on the material itself other than the geometry and (2) whether it is possible to use nanofiller materials together with the resin. This seems to the reviewer to be a good match for future directions.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

It wasn’t clear in the presentation to this reviewer where the university partner contributed but several publications had the team lead and the university as authors which, the reviewer believes, shows good collaboration. The reviewer suggests that it may be preferable to identify contributions from each partner in the presentation.

Reviewer 2:

The collaboration seems to this reviewer to have been very productive. The reviewer questions whether there might be any intellectual property (IP) issues that could be problematic.

Reviewer 3:

The collaboration within the project team appears to this reviewer to be adequate, though the reviewer is not 100% clear as to who is doing what work exactly.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer suggests that the future work include a baseline comparison.

Reviewer 2:

This reviewer notes that there is a healthy balance with the materials and the design development. The reviewer asks if the team could explain the work of ORNL and the partner company on how IP issues have been resolved.

Reviewer 3:

This reviewer believes that the current/expected collaboration with Ford is a positive development that could give the project support toward continuing the improvements in applicability to vehicle designs.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer affirms that the project supports the VTO overall goals.

Reviewer 2:

This reviewer states that the project is very much aligned with the VTO program goals.

Reviewer 3:

According to this reviewer, the relevance of the project is high, though there are questions related to the applicability of the approach. Aspects of the presentation were not clear to the reviewer, especially in regard to the self-sensing idea and how the ability of the team to tailor stiffness can be used for self-sensing. These ideas were clarified during the Q&A.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer believes that the resources are sufficient for both the sensing experiments and 3D printer development.

Reviewer 2:

This reviewer found that the resources have been well-utilized in a timely fashion and suggests that there is a need to report any deviation from the original plan and budget.

Reviewer 3:

The resources needed to conduct the project appear to be sufficient in this reviewer’s opinion.

Presentation Number: MAT149
Presentation Title: Shear Assisted Processing and Extrusion (ShAPE) of Lightweight Alloys for Automotive Components
Principal Investigator: Scott Whalen (Pacific Northwest National Laboratory)

Presenter

Scott Whalen, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

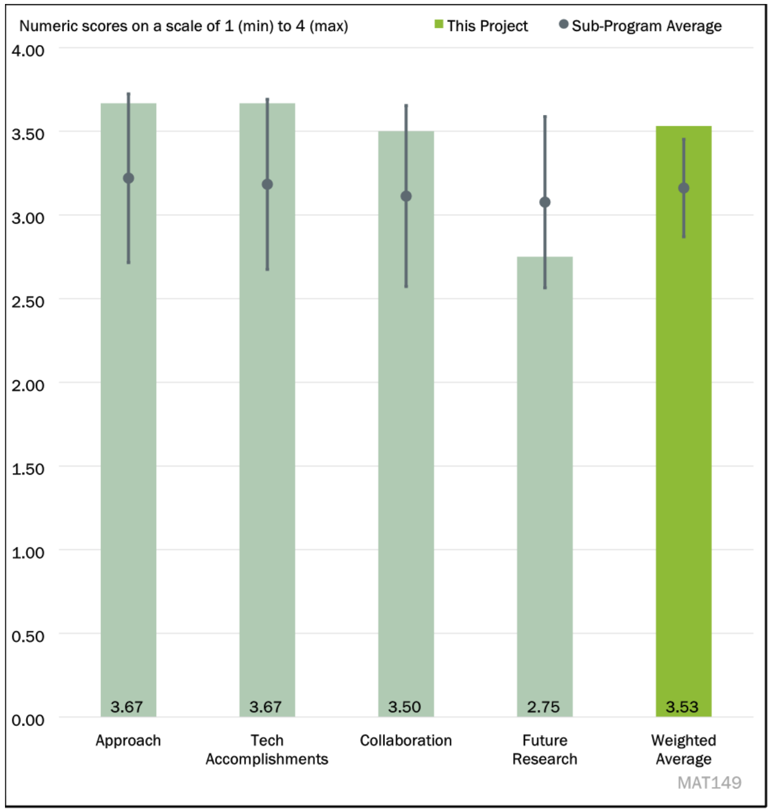

Figure 5-1 - Presentation Number: MAT149 Presentation Title: Shear Assisted Processing and Extrusion (ShAPE) of Lightweight Alloys for Automotive Components Principal Investigator: Scott Whalen (Pacific Northwest National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer praised the project as being complete and having addressed the technical barriers in a timely manner. Specifically, it was demonstrated that the shear assisted processing and extrusion (ShAPE) process can be used to produce components with desired microstructures and properties. Additionally, scrap metal can be utilized to enhance recycling and reduce the carbon footprint for manufacturing.

Reviewer 2:

This reviewer pointed out that the project is completed; the aim was to develop the ShAPE process and demonstrate the feasibility of recycling Al alloys; the objective was completed successfully as the technology is being tested at an industrial partner’s site. The technical barriers were resolved with the demonstration project.

Reviewer 3:

This reviewer suggested that the project should really address the challenge of using post-consumer scrap (not just the manufacturing scrap), which would have more impact to the applications.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer found that the project made good progress in addressing manufacturing scrap.

Reviewer 2:

This reviewer stated that the team had developed and demonstrated the process.

Reviewer 3:

This reviewer said that all the milestones on the project have been met.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

To this reviewer, it seems that Magna is very much involved in the collaboration.

Reviewer 2:

This reviewer affirmed that the project is well supported by industry partners; the team had many meetings and technology transfer trials, which were well coordinated.

Reviewer 3:

This reviewer believes that the main collaboration has been with Magna and its subsidiaries.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer noted that the project is complete; commercialization efforts are underway through negotiations with industrial partners.

Reviewer 2:

This reviewer felt that it would be good to target a product for commercialization in collaboration with Magna or another supplier. It seems to the reviewer that the commercialization aspect is missing from the future work plan. The reviewer mentioned that there will be a new LightMat project to develop a continuous extrusion process and asked whether a target product/component has been chosen.

Reviewer 3:

This reviewer believes that the project should address the challenge of using post-consumer scrap (not just the manufacturing scrap) in the future.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer found the project to be relevant to lightweighting and environment protection.

Reviewer 2:

This reviewer believes that the process development is needed to produce light metals (Al and magnesium) with less difficulties. Lightweighting is needed for the vehicle efficiency and this project develops an enabling technology to produce light metal components with enough performance.

Reviewer 3:

This reviewer affirmed that the project is relevant to vehicle lightweighting for less energy consumption, materials recycling, and lowering of GHGs.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer commended the team for having had good delivery of the project and also for having interacted with the industrial partners, as well as for having the results well disseminated.

Reviewer 2:

This reviewer said that the project was completed within the budget and allocated resources.

Presentation Number: MAT152
Presentation Title: A Hybrid Physics-Based, Data-Driven Approach to Model Damage Accumulation in Corrosion of Polymeric Adhesives
Principal Investigator: Roozbeh Dargazany (Michigan State University)

Presenter

Roozbeh Dargazany, Michigan State University

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

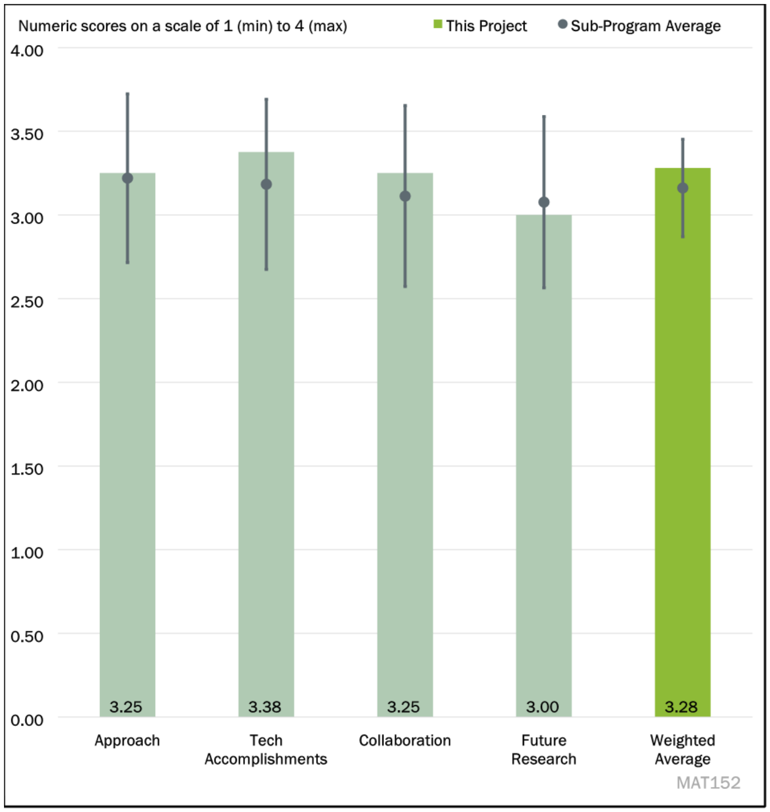

Figure 5-2 - Presentation Number: MAT152 Presentation Title: A Hybrid Physics-Based, Data-Driven Approach to Model Damage Accumulation in Corrosion of Polymeric Adhesives Principal Investigator: Roozbeh Dargazany (Michigan State University)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer wrote that the barriers and technical targets identified were the lack of reliable joining technology for dissimilar materials, the lack of cost-effective tests for evaluation of corrosion, the lack of a constitutive model capable of predicting corrosion, a predictive modeling tools with a prediction error less than 10%, and a lack of validated test protocols for predictive modeling tools. The overall objectives were to develop a theoretical model that describes damage accumulation in a constitutive behavior with respect to deformation, vibration, hydrolysis, thermo-oxidation and photo-oxidation. The model that was developed can be used to predict the failure of cross-linked polymeric adhesives within a 10% error with respect to damage accumulated by environmental and mechanical loads. Predicting failure in adhesives of dissimilar materials is important for the use of lightweight materials leading to vehicle mass reduction and expediting the design of composite joints in vehicle structures for lightweighting to address the VTO Materials subprogram targets and goals for joining of lightweight materials. According to the reviewer, there is also a need to reduce the time and cost required for testing corrosion failure, which makes the use of lightweight materials more attractive to original equipment manufacturers (OEMs) and provide them with an improved computer-aided engineering prediction capability to achieve a reliable service-life of joints. This project addresses the needs for joining dissimilar materials used in 15 different components used in commercial vehicles. The principal effort in Fiscal Year 2022 was to complete the software predictions for sample adhesives exposed to all combinations of corrosion mechanisms under laboratory conditions. This approach addresses the barriers and technical targets for determining reliable joining technologies for dissimilar materials, the lack of cost-effective tests for evaluation of corrosion, and the lack of a constitutive model capable for predicting corrosion, specifically. This was a three-year research and development (R&D) project that appears well designed to address the barriers and targets within a reasonable timeframe.

Reviewer 2:

This reviewer found that, while the project approach includes extensive modeling and validation efforts, it is not completely clear how effective this will be at enabling industry (including adhesive manufacturers and automotive OEMs) to improve on the current state of adhesive development and evaluation in real world automotive OEM usage.

Reviewer 3:

This reviewer commended the team for a good effort with complete results.

Reviewer 4:

According to this reviewer, while the research objective is well-outlined, it is difficult to follow the detail, which makes it very difficult to evaluate the technical approach of the present study appropriately. The present project claims that it is a physics-based data-driven research, but it is hard to understand how or what physics have been incorporated in the data analytics.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer characterized the project was to develop a theoretical model to describe damage accumulation in constitutive behavior with respect to deformation, vibration, hydrolysis, thermo-oxidation and photo-oxidation as well as a combination of these mechanisms, specifically to predict failure of cross-linked polymeric adhesives due to damage from environmental and mechanical loads. A thermal and mechanical model was developed to predict the constitutive behavior of adhesives through thermo-oxidative aging using an approach that assumed a dual network hypothesis. This achieved the first validated model of thermal and mechanical effects covering permanent set and polymer relation. The effects of vibration were added to model the constitutive behavior of thermo-oxidative aging and vibration concurrently, assuming that the mechanical and environmental aging are two parallel mechanisms. Fatigue was added to the thermal portion to model the constitutive behavior of thermo-oxidative aging and fatigue using an accumulated damage approach. A continuous network hypothesis was used to develop a model that predicted the effects of ultraviolet light coupled with thermal and mechanical failure mechanisms. For hydrolysis and mechanical failure mechanisms, silicone was examined as the dominant plasticization and chain scission with decrease in stress and increase in strain. Studies of polyurethane showed high chain scission with decrease in stress and a decrease in strain. The strain energy of the material in all states of aging was modeled for hydrolysis, thermal, and mechanical mechanisms. Machine-learning was used to reduce the order for modeling thermal aging and mechanical effects with a goal of developing a model for the constitutive behavior of adhesives through thermo-oxidative aging. All these efforts achieved the first validated models for each of the mechanisms being studied. According to the reviewer, these were significant accomplishments toward meeting the technical target for the lack of a constitutive model capable for predicting corrosion and was consistent with the project plan.

Reviewer 2:

In this reviewer's estimation, the project team has substantially met the extensive objectives of their project plan including validation of individual models for predicting adhesive performance degradation resulting from loading, vibration, thermal, ultraviolet, and hydrolysis inputs, as well as others.

Reviewer 3:

This reviewer believes that the progress was very good this cycle.

Reviewer 4:

While noting that very detailed information was provided, this reviewer found it very difficult to understand the accomplishments and progress at a high level. Thus, it was very difficult for this reviewer to properly evaluate the technical accomplishments and progress.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

This reviewer lauded the project as outstanding for the level of collaboration that was formed. It included academia (Michigan State University – the project lead), two chemical companies (Dow and Parker-Lord), a high-performance modeling (HPM) group, a testing company (Endurica), a tier one supplier (Bosch), and a firm that deals in quality assurance and test standards (JDV). According to the reviewer, this project had the best collaboration of any of the projects reviewed.

Reviewer 2:

The reviewer concluded that the project has displayed good collaboration and coordination from a sizable group of industry and academic partners to achieve its goals on a timely basis. The collaboration could have been improved by the inclusion of a substantially involved automotive OEM.

Reviewer 3:

This reviewer found good coordination among teams.

Reviewer 4:

This reviewer believed that it appears that the majority of work has been done at the leading institute, but it is unclear what work has been done by other team members.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer noted that the project ended in December 2022; however, future research that was recommended included studies on the degradation of adhesion properties at the substrate/adhesive interface, examining other parameters such as conductivity, and investigation of data minimization for training/validation of multi-agent simulators.

Reviewer 2:

This reviewer stated that the project has ended, so there can be no future research as part of this project.

Reviewer 3:

This reviewer said that the project has ended.

Reviewer 4:

This reviewer found that the proposed future works appear to be reasonable.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer confirmed that the project addresses the Materials subprogram barrier of a lack of reliable joining technology for dissimilar materials, including lack of cost-effective tests for evaluation of corrosion, lack of constitutive model capable of predicting corrosion, and lack of predictive modeling tools.

Reviewer 2:

This reviewer found that the project was very relevant to the VTO Materials subprogram objectives for predicting failure in adhesives of dissimilar materials that is necessary to facilitate use of lightweight material for vehicle mass reduction, accelerating the design of composite joints in vehicle structures for lightweighting, improving computer-aided engineering prediction capabilities to achieve a reliable service-life of joints, and reducing the time and cost required for testing corrosion failure which makes the use of lightweight materials more attractive for OEMs.

Reviewer 3:

This reviewer held that the objective of the project is well-aligned with the EERE VTO's mission space.

Reviewer 4:

Work is relevant to VTO's mission.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer opined that the resources provided by DOE and the collaborators have been sufficient to enable the team to accomplish all of their milestones in 4 years.

Reviewer 2:

This reviewer pointed out that in Fiscal Year 2022, this project received almost $1 million of DOE funding with almost $500,000 from the collaboration partners which is a 33% cost share. The collaborators were well capable of providing the resources needed in their areas of specialization. This was sufficient funding and personnel/facility resources for a project that completed in 2022.

Reviewer 3:

This reviewer confirmed that the project has sufficient resources to carry out the proposed research.

Reviewer 4:

This reviewer found that the project was given good resources across the board.

Presentation Number: MAT159
Presentation Tile: Cost Effective Lightweight Alloys for Electric Vehicle Propulsion, Fundamental Fatigue and Creep in Advanced Lightweight Alloys
Principal Investigator: Amit Shyam (Oak Ridge National Laboratory)

Presenter

Amit Shyam, Oak Ridge National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 25% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

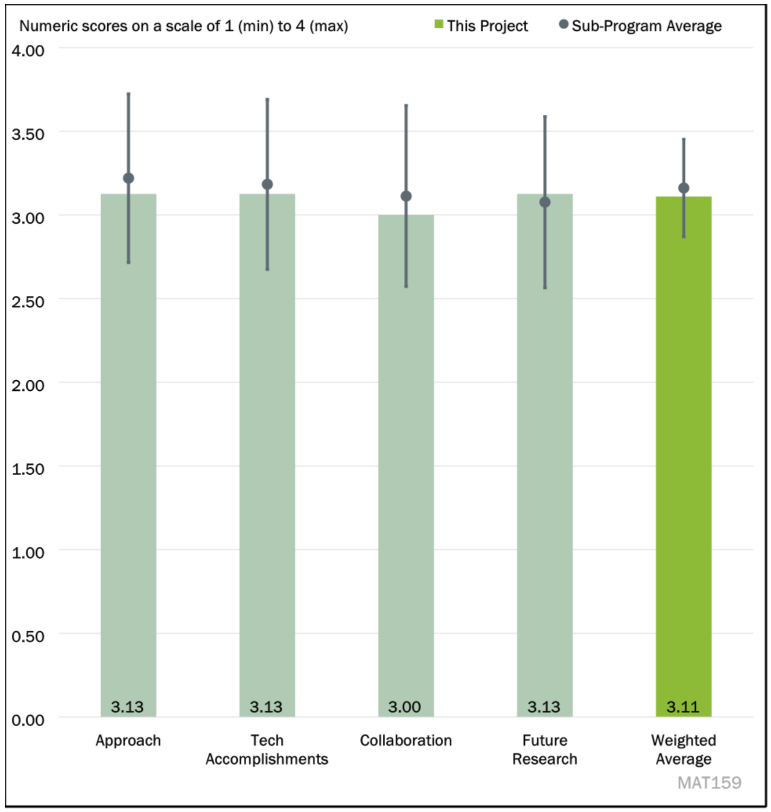

Figure 5-3 - Presentation Number: MAT159 Presentation Title: Cost Effective Lightweight Alloys for Electric Vehicle Propulsion, Fundamental Fatigue and Creep in Advanced Lightweight Alloys Principal Investigator: Amit Shyam (Oak Ridge National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer found the work scope to be well defined to address the key technical barriers of creep and fatigue for lightweight propulsion materials for electric vehicles (EVs). Using modeling and advanced characterizations, the fundamental mechanisms for the creep and failure in Al alloys have been studied to help design alloys with improved properties for conductor and structural applications in EVs.

Reviewer 2:

This reviewer believes the technical barriers, from the microstructural issues to the materials degradation issues, appear to be systematically addressed. The reviewer is concerned, however, that standards or matrices for materials issues, like creep to be tested, are lacking, for example, the limits of acceptability for creep for instance. According to the reviewer, the Principal Investigators (PIs) admitted that there are none because they do not know what they would be. This is a serious concern for the reviewer.

Reviewer 3:

According to this reviewer, the program presents a classical set of materials issues and a good balance of physical metallurgy and fundamental microstructural assessment. While it has been mentioned in a previous review, the development of the aluminum-copper-manganese-zirconium (ACMZ) alloy for the suggested use in brake rotors seems to be a stretch. Brake performance is measurable as a balance between wear properties and cost (as what is essentially a consumable component…) and less dependent upon traditional high temperature strength. Aging behaviors of Al precipitate structures (even L12) would likely lead to other performance issues (fatigue crack growth, warpage from thermal cycling). According to this researcher, this research is reflective of a great solution still in search of a problem.

Reviewer 4:

This reviewer found the technical barriers outlined to be very broad and did not see a project plan presented. This gap made this question hard for the reviewer to evaluate and hard to discern if the work accomplished was well aligned with the most significant barriers.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer pointed out that *in situ* studies have been completed to understand the creep mechanisms in a cast Al alloy and baseline creep properties have been established. The project is on track with the milestones.

Reviewer 2:

This reviewer found that the program is demonstrating compelling results in direct comparison curves, and the team is revealing some good interpretations of microstructural responses even when property improvements are not being realized.

Reviewer 3:

This reviewer believes that the project made significant progress linking mechanisms to creep resistance, but without a project plan and context for prior work this was hard to benchmark.

Reviewer 4:

To this reviewer, the main concern is the lack of performance targets in this work. It is possible that the PIs are well off the targets that need to be achieved since they are not currently measuring results to such targets. Also, photos of the microstructural analyses that yielded the hypothesis on Slide 10 of the presentation would have been helpful. The reviewer questions why peak hardness temperatures on Slide 15 are different from the aging temperatures employed for aging (Slide 16). The reviewer notes that the material's hardness between 400°C and 425°C (Slide 15) is over 50 MPa.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer noted that the project is a collaborative work with three national laboratories as part of the Propulsion Materials Core Program. Within the core program, this project is well aligned with other tasks, including the advanced characterizations using Spallation Neutron Source. Additionally, there has been collaboration with Northwestern University and an industry partner.

Reviewer 2:

This reviewer called the team strong but said that the collaboration is relatively limited. For work with such practical applications (at least in principle), engagement with potential end users would be highly beneficial.

Reviewer 3:

This reviewer complained that the only mention of collaborators is on Slide 20 finding the collaboration efforts not clear from the work presented, or what the role(s) of Northwestern University and Nano Al is/are. It is apparent that they are involved in other tasks under the same project. How exactly they are coordinating is not clear to this reviewer.

Reviewer 4:

This reviewer was also disappointed that, while the various collaborators were identified, what roles they played and how they contributed were not addressed.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer says that the future research being proposed builds on the results and accomplishments of the program.

Reviewer 2:

This reviewer noted that the future work is defined for only until the end of the calendar year, which entails demonstration of the enhanced creep resistance in alloys with different compositions, *in situ* neutron creep testing, and fatigue properties of the additively manufactured alloys. The reviewer would have liked to see long term plans such as working with an industry partner for development of laboratory scale prototypes to show how the new materials would be transitioning into a product. While the reviewer concedes that it may be early but believes that some kind of a road map would be helpful.

Reviewer 3:

This reviewer believes the tests laid out are great and would help address many unanswered questions. This reviewer assumes future work is the work highlighted on Slide 3 and Slide 21 and not just on Slide 21 but asserts that what is laid out on Slide 21 by itself is inadequate. A technical gap that has not been addressed is the performance targets that are being tested to. For instance, how much creep is acceptable in rotor materials, and do the materials being tested meet the requirements.

Reviewer 4:

This reviewer complains that the proposed future research does not describe what these results would enable and how significant they would be.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer affirms that this project contributes to materials advancements necessary for efficient electrification of cars.

Reviewer 2:

This reviewer states that the work is highly relevant to the focus of this thrust area.

Reviewer 3:

This reviewer says that the project aligns with incorporating metals with less weight into the vehicle.

Reviewer 4:

This reviewer believes that the project is very relevant for the improved lightweight alloys for structural and conductor application in EVs, which can lead to increased efficiencies and range for the vehicle.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer found that the resources and capabilities seem adequate.

Reviewer 2:

This reviewer believes that the mechanical property testing is readily available to the team since the project requires extensive, time-consuming creep testing. Further, beam line time allocation at the neutron source is not an issue in case some experiments are needed in the latter part of the project.

Reviewer 3:

This reviewer referred to having pointed out during the question and answer (Q&A) section that industrial perspective on the acceptable levels of creep was not known to the principal investigator. This seems like a needed collaboration/resource.

Reviewer 4:

This reviewer lamented that there is no way to accurately tell whether the resources provided will be adequate for the remaining research, except for the word of the PIs. Although total share work completed (75%) and total budget ($1.97 million) are provided, the total budget spent to date is missing. The total funding spent in the task presented is not provided either. Thus, the reviewer finds that vital information needed to make this determination has not been provided.

Presentation Number: MAT160
Presentation Title: Cost Effective Lightweight Alloys for Electric Vehicle Propulsion, Hybrid Dispersion Strengthened Al matrix composites for higher efficiency EV powertrains
Principal Investigator: Mert Efe (Pacific Northwest National Laboratory)

Presenter

Mert Efe, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

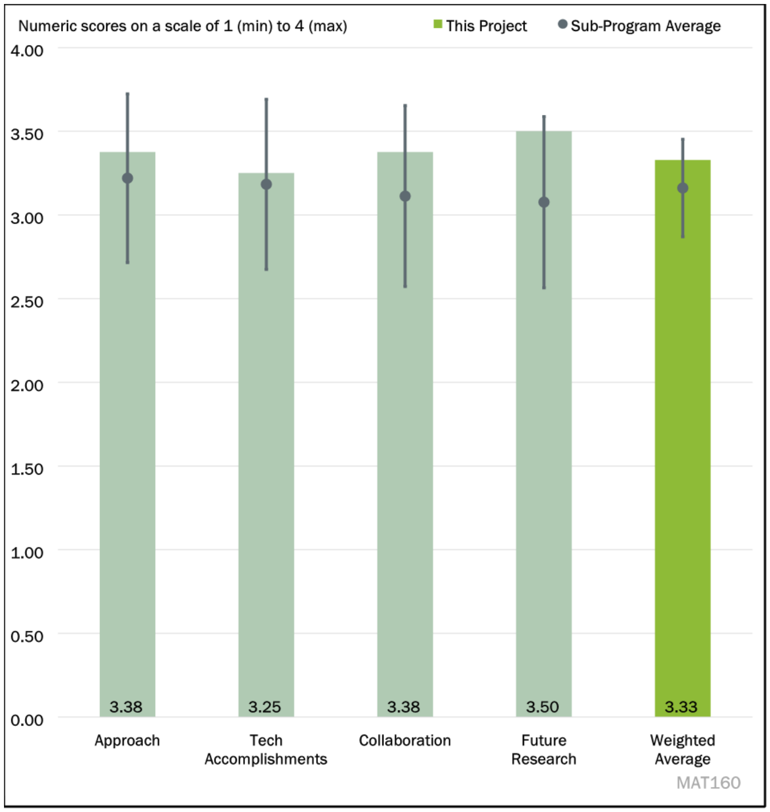

Figure 5-4 - Presentation Number: MAT160 Presentation Title: Cost Effective Lightweight Alloys for Electric Vehicle Propulsion, Hybrid Dispersion Strengthened Al matrix composites for higher efficiency EV powertrains Principal Investigator: Mert Efe (Pacific Northwest National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer found the project to be well designed and well-planned with a focus on dispersion-strengthened Al matrix composites for higher-efficiency electric vehicle (EV) powertrains, including brake rotors and gearboxes. The technical barriers below are addressed, including cost of metal matrix composites (MMCs) (including raw material prices), compositing, processing, finishing costs, and the high strength and wear resistance of competing steel and cast-iron parts.

Reviewer 2:

This reviewer called the project scope and timeline well defined. According to the reviewer, however, the target properties for the MMC for a specific application such as brake pads are not clear including what strength and hardness values are targeted, and what target is to achieve the properties of a cast iron brake pad.

Reviewer 3:

This reviewer praised the technical approach as being very well-designed and straightforward. The hypothesis is reasonable and clearly articulated/presented.

Reviewer 4:

This reviewer found that, overall, the project is well designed, and three milestones have been achieved. Technical barriers were addressed, although open questions have also been presented. It was not clear to the reviewer whether this was for work beyond the current project or to be addressed in this project's scope. The reviewer noted that it has not been demonstrated that Al MMCs are close to being used but, rather, it was mentioned that manufacturers state that steels are still better; good comparison with iron was provided.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer found that the team overcame the identified barriers to the more widespread use of Al MMCs for vehicle light-weighting. The approach to performing the work is using *in situ* stir and squeeze casting targeted towards the brake application with lower cost to compete with cast iron. The composites selected were A206 as the matrix and *in situ* titanium diboride (TiB2) for cost and recyclability. The team achieved finer grains and uniform distribution of TiB_2 with squeeze casting. The wear rate testing shows cast iron and MMC have similar wear rates.

Reviewer 2:

This reviewer said that the progress made for processing of the Al-TiB_2 composites is good. Hardness of the MMCs are comparable to the cast iron, but it is not clear what the optimum target volume percent of the reinforcements is. Data have been presented on MMCs with TiB_2 ranging up to 24%, but it was not shown how the higher loadings would impact the cost targets, if at all.

Reviewer 3:

This reviewer believes that the team has made excellent progress, and the results are clearly presented. The team has chosen a benchmarking system (i.e., cast-iron) to compare the results of the proposed materials system.

Reviewer 4:

According to this reviewer, hardness was shown to be close to that of iron. Minimal porosity has been achieved and mixing to 3mm depth with relevance to certain surface applications has been shown. Increase of hardness in reinforced alloys was achieved compared to base alloy. A gear shaped alloy with uniform hardness distribution has been demonstrated, and its hardness increase has been compared to the base material. Al_3Ti needle-shaped particles still appear but the formation/density is suppressed.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

According to this reviewer, the team, led by Pacific Northwest National Laboratory (PNNL) partnering with Loukus Technologies, Inc. and Oak Ridge National Laboratory (ORNL) is well organized and progressed the tasks effectively. In addition, a collaboration with a brake rotor manufacturer has been initiated to perform a more detailed evaluation for meeting the industrial requirements.

Reviewer 2:

This reviewer noted that the team has now started a collaboration with a brake manufacturer, which the reviewer believes is good. Additionally, the project in now shifting focus to include ACMZ alloys and collaboration with ORNL has been initiated.

Reviewer 3:

This reviewer opined that collaboration and coordination across the project team appears to be reasonable.

Reviewer 4:

The reviewer stated that the two partners seem to collaborate very well to achieve the milestones. The team is collaborating with another national laboratory, ORNL, for some testing and is reaching out to manufacturers. The reviewer suggests that it would be nice to see what the interactions with manufacturers have so far, and how the collaboration with ORNL works. (The presenter did mention that manufacturers say that the steels are still better than Al MMCs.) Overall, the interactions seem to be working out.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer pointed out that the team plans for future work focusing on completing wear tests for the brake rotors with new pads and discs, completing tensile tests for the friction-consolidated composites, and obtaining hybrid composites with sub-micron and micron-sized particles with the friction consolidation route.

Reviewer 2: .

This reviewer considers the proposed future research to be reasonable and well-designed to continue the progress made to date.

Reviewer 3:

The future work seems to this reviewer to be reasonably planned for the remaining time. Techniques have been demonstrated as well as gear manufacturing. Project completion seems doable within the next few months.

Reviewer 4:

This reviewer suggested that the proposed future work could have more clarity in terms of developing a core/shell configuration and that it is not clear what is being achieved by taking this approach. It would be good to focus on the development of a specific component (gears/brake pads) and to fabricate such a component and have it tested in an actual environment.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer finds the scope of work is well aligned with the overall VTO subprogram objectives.

Reviewer 2:

This reviewer believes that using new lightweight alloys with improved properties can help with vehicle weight reductions, especially if used for currently high-density components such as brake pads, etc.

Reviewer 3:

This reviewer affirmed that, if successful, Al MMCs can replace heavier cast iron counterparts for weight savings and reduced particle emissions, which is highly relevant with the EERE VTO's mission space.

Reviewer 4:

This reviewer stated that the project supports the Materials subprogram, as it focuses on improving manufacturing and properties of Al-based alloys while aiming at cost effective approaches.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said that the team has sufficient resources to carry out the planned tasks.

Reviewer 2:

This reviewer believes that the project has appropriate resources to carry out proposed research.

Reviewer 3:

According to this reviewer, since more than 80% of the project is complete, it seems that there is no need for additional resources to accomplish the remainder of the project.

Reviewer 4:

This reviewer asked, based on his understanding that the work scope now includes looking at ACMZ alloys in collaboration with ORNL, how the ORNL effort is to be supported.

Presentation Number: MAT174
Presentation Title: Carbon-Fiber Technology Facility (CFTF)
Principal Investigator: Merlin Theodore (Oak Ridge National Laboratory)

Presenter

Logan Kearney, Oak Ridge National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 67% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 33% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

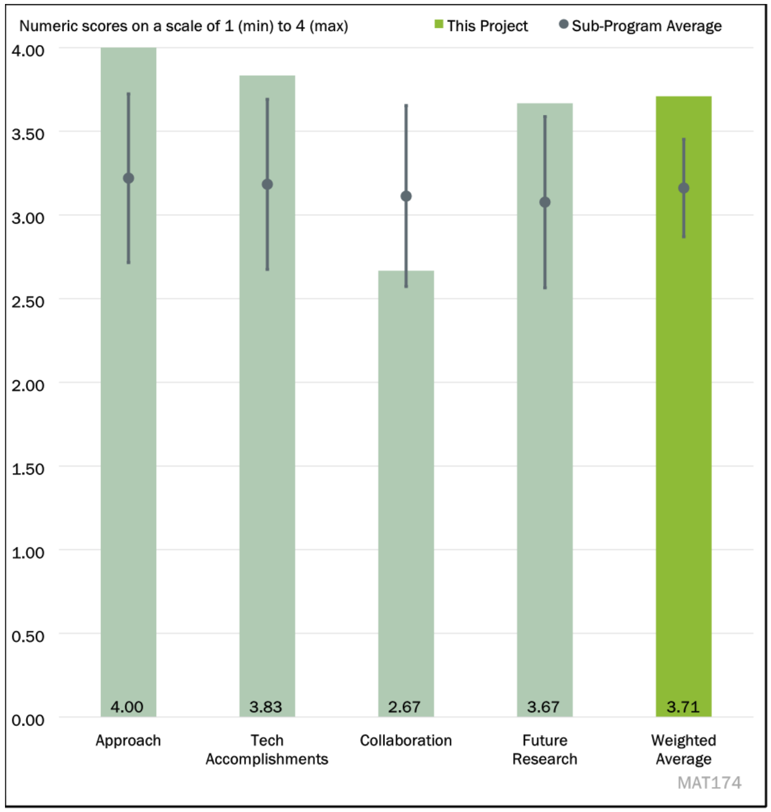

Figure 5-29 - Presentation Number: MAT174 Presentation Title: Carbon-Fiber Technology Facility (CFTF) Principal Investigator: Merlin Theodore (Oak Ridge National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer found that the work presented is a nice approach to trying to process pitch-based carbon fiber. This is the type of work that the reviewer would like to see being done through the funding sent to the Carbon Fiber Technology Facility (CFTF). The past AMR presentations just gave a very high-level overview of what CFTF has done over the years. But, this year, actual research was discussed. The reviewer would like to see a similar level of detail about actual research in the future. The reviewer found it nice to have somebody presenting, as distinct from last year's presentation, which was just a recording. The timeline is very short for this project, but the reviewer hopes that it will be successful by the end of the year in order to warrant continued research on the topic.

Reviewer 2:

The reviewer noted that the Technical Integrated Approach in the presentation provided a table that identified high-potential low-cost alternative precursors, such as thermotropic low-cost pitch materials, and the change in cost and energy compared to the baseline polyacrylonitrile (PAN), which addressed the barrier for the cost of CF manufacturing. A stationary catalyst bed based on metal atom-containing carbon foams was planned to be used to enhance mesophase formation in a flow through reactor and, therefore, enhance the pitch quality. A multi-scale approach to develop optimal mechanical properties of resultant CF from alternative (pitch-based) precursors and recycled materials was presented, which should define the pitch quality. The CFTF was proposed as the manufacturing facility to address technology scaling, intermediate formation, composite product validation, and market development and commercialization, including recycling. This CFTF and this type of project has a history going back to 2013 and has, in the view of the reviewer, always included well-designed projects, as evidenced by the flow diagram on Slide 6 showing the steps involved from material identification to market performance and evaluation. The timeline for precursor development is continuous and has been since 2013. The CFTF is funded each year by three EERE offices, so a specific timeline is not applicable.

Reviewer 3:

This reviewer points out that PAN-derived CFs are expensive, and it has been challenging to reduce PAN precursor cost and conversion cost (wet spinning, oxidation and carbonization). It is urgent to find/develop alternative low-cost precursors (to secure supply chains). The project has demonstrated a new route to producing low-cost pitch precursors. With the conversion processes developed in the project, the pitch CFs are expected to meet the cost ($5 per pound) and property targets (strength 250 kilopounds/square inch (ksi) and modulus 25 million pounds/square inch (msi). The project presents a clear scale-up roadmap and a technology transfer (to industry) plan.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer found that, despite this being early on in the project and a short project, great accomplishments were achieved. Significant progress has been made in creating the stationary catalyst bed. The graphite foam inserts with integrated catalysts were successfully synthesized and characterized. The reviewer looks forward to seeing the results from operating the reactor bed and forming the resulting fibers.

Reviewer 2:

This reviewer notes that pitch CFs often exhibit high modulus. To achieve high strength, pitch precursor fibers need to have smaller diameters and lower defects (porosity). The pitch CFs developed in this project exhibit about 15 microns (μm) diameter, this is encouraging. The precursor carbon yield is promising. The reactor construction is novel.

Reviewer 3:

One objective of the project plan noted by this reviewer is to demonstrate advanced fiber production using lower-cost precursors. One task that supports this objective is to investigate potential alternative CF precursors. Thermal characterization of six precursors was completed and the weight percent of CF was determined for each precursor. Heterogenous catalyst coating formulations were identified that will allow functional characterization of the CFs produced. Scanning electron microscopy was used to characterize low, medium and high loadings of the catalyst coating on the CFs. A prototype flow-through reactor was fabricated and tested by producing foam surrogates to be used for initial coating experiments. All these factors indicate good progress for successfully completing the task and meeting the objective of the project plan.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

This reviewer was not aware of any specific collaborations being mentioned, but this was only a one-year project, which did not need a big collaborative effort, so the reviewer finds it hard to judge this small internal project on its coordination across multiple teams. The reviewer notes that it was mentioned that a couple of companies have been identified that are interested in the technology, but the specific companies were not named, which the reviewer finds acceptable at this stage of the project. If there is another AMR presentation on this work next year, the reviewer would like the presentation to include what companies are working with ORNL on commercializing this.

Reviewer 2:

This reviewer pointed out that this phase of the project is in the early stages of R&D so there is not much collaboration outside the ORNL CFTF. IP development is being driven internally by ORNL. Once the initial proof of concept phase is complete, existing collaborative partnerships directed toward pitch and graphite foam are expected to be initiated to further develop the technology.

Reviewer 3:

The project demonstrates to this reviewer a close collaboration inside ORNL (the team consists of several CF experts). The project team has already reached out to collaborative partnerships in pitch and graphite foam.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The proposed future research and remaining challenges are clearly defined to the satisfaction of this reviewer. The targeted goals of producing CF and determining the structure property relationships for the candidate pitches are achievable targets by the end of the project. The targeted properties are clearly described in the milestone table and, the reviewer believes, should be achievable.

Reviewer 2:

The future plan is clear and makes sense to this reviewer. Pitch CFs often show low strength and strain compared to PAN carbon fibers. Pitch precursor quality is of importance to achieving higher strength and strain. The project team is expected to show how to reduce or eliminate defects from the precursor fibers in the melt spinning.

Reviewer 3:

This reviewer found that, because the project is in the early stages of R&D, there is a source-to-source variation for each isotropic precursor. CF structure/property relationships will need to be determined from each of the candidate pitches. The compatibility of the prototype reactor with lower polycyclic aromatic hydrocarbons still needs to be determined. More research will be required in each of these areas, so that the reviewer believes that it is too early to determine the extent that the proposed future work will contribute to achieving the targets for this project.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer notes that the project is very relevant to the vehicle lightweighting objectives within DOE. The project has a clear vision of how it will lightweight vehicles at a reduced cost by successfully developing this processing method for pitch-based CF.

Reviewer 2:

The project, according to this reviewer, is relevant to supporting the overall VTO Materials subprogram objectives to address significant technology gaps for lightweight structural materials like polymer composites and is addressing key challenges in electrical conductivity, thermal conductivity, magnetic materials, and high-temperature operation currently limiting advances in lightweight materials. This project also addresses the objective to support RDD&D of materials that will increase recyclability.

Reviewer 3:

This reviewer points out that CFs are critical materials for lighter and smarter vehicles EVs. In addition, CFs enable many functionalities, such as sensing and electromagnetic interference (EMI) shielding. The main barrier is the high cost of CFs. It is urgent to develop low-cost, high-performance CFs in the United States. The project aims to develop low-cost alternative CF precursors and conversion processes. This also helps secure supply chains to ensure economic prosperity and national security, according to the reviewer.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer believes that CFTF has sufficient funds to continue projects like this, and they should continue to fund these smaller projects within their large annual budget.

Reviewer 2:

The reviewer points out that CFTF is funded $11 million annually by three EERE offices that support projects like this one. The CFTF includes a 42,000 square foot facility with a capacity of up to 25 tons of CF per year with a R&D staff of scientists, engineers, and manufacturing specialists that are sufficient to execute this project.

Reviewer 3:

This reviewer describes how the CFTF is a unique national resource to assist industry/academia R&D in overcoming the barriers of advanced fiber cost, technology scaling, intermediate formation, and composite product and market development. The CFTF is equipped with all resources needed for the project.

Presentation Number: MAT196
Presentation Title: High Temperature Carbon Fiber Carbonization via Electromagnetic Power
Principal Investigator: Felix Paulauskas (Oak Ridge National Laboratory)

Presenter

Felix Paulauskas, Oak Ridge National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

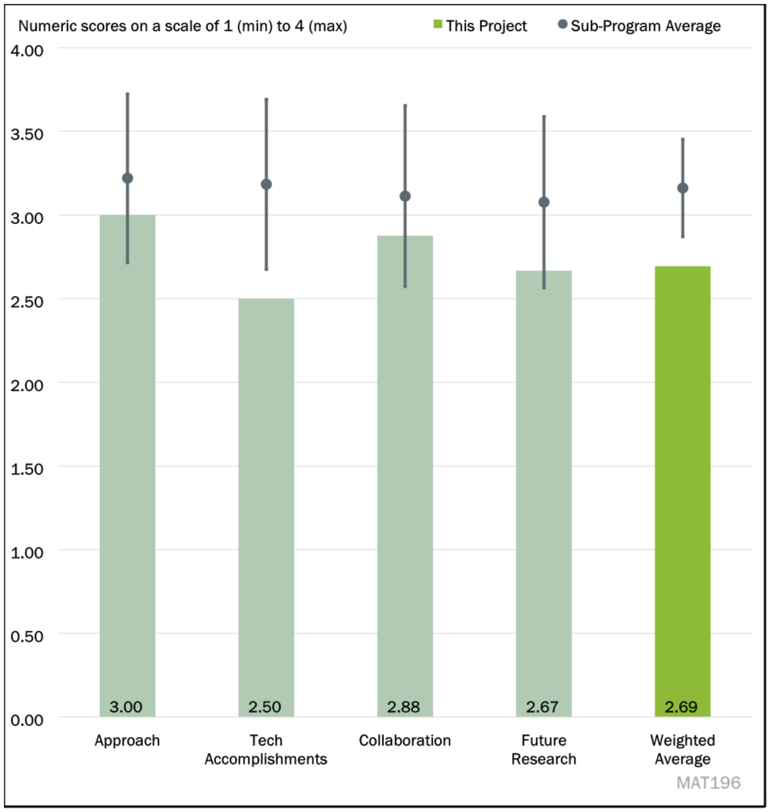

Figure 5-30 - Presentation Number: MAT196 Presentation Title: High Temperature Carbon Fiber Carbonization via Electromagnetic Power Principal Investigator: Felix Paulauskas (Oak Ridge National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer said that the approach is adequate for the goals that have been laid out.

Reviewer 2:

This reviewer found that the technical barriers included the reduction of energy consumption in the CF conversion process and the total CF cost, as well as reduction of the required processing time for carbonization to increase the overall throughput for the manufacturing process. This project is a continuation of a previous project with similar goals, so this project is well designed based on previous results and the original timeline was reasonably planned to accomplish addressing the technical barriers. Delays because of contracting issues and equipment deliveries caused significant slippage in meeting the project milestones. The approach is to directly couple the thermal energy from an energy source to the CF using electromagnetic coupling to realize energy savings. This is considered by the reviewer to be a reasonable approach to overcoming the technical barrier of reducing energy consumption in the CF conversion process.

Reviewer 3:

This reviewer determined that the team has identified a viable approach to the high temperature carbonization (HTC) of pre-cursors for CF production. Its method of directed energy tuned to processing fiber without heating the entire chamber volume is useful and will be an important part of increasing fiber capacity while reducing total energy consumed in fiber manufacturing.

Reviewer 4:

This reviewer considers the project to be an excellent option for using dielectric heating for HTC; however, the milestones are focused on equipment set-up and deployment, rather than assessing the efficacy of the process and parameters on carbonization, CF material performance, and techno-economics, even though they are listed as the objectives to be achieved in the project. The reviewer is unclear as to whether, on a holistic level, material performance and process development milestones were defined for earlier portions of the project, which is believed to be important to know especially since the project is ending in June 2023.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

To this reviewer, it is evident from the work that the energy consumption in this process, compared with conventional methods, is less. However, the team needs to demonstrate that the costs per pound of manufacturing the CF is lower, and by how much, compared with conventional methods.

Reviewer 2:

This reviewer notes that the high-temperature conversion applicator system and its seven sub-system components were described. Some of the sub-system components caused project delays that could not be overcome. Additionally, some equipment was impaired while attempting processing fiber for energy consumption evaluation, causing more delays. This resulted in abnormal operation, causing material damage and contamination, and damage to the transmission line and some internal parts. Although the system was previously demonstrated in 2022 with two 50,000 filament tows achieving 550 ksi tensile strength and 29 Msi modulus, not much else has been accomplished technically, according to the reviewer, toward high-temperature conversion of CF because of problems obtaining equipment and getting the modified system operational.

Reviewer 3:

This reviewer has moderated the scoring as a direct result of the time lost due to the failure of the HTC equipment, which was severely damaged during trials. With that said, the team should be commended, according to the reviewer, for demonstrating the viability of the electromechanical-driven HTC. It is extremely promising that this technology has (without the ability to iterate equipment and improve/tune the process) created CF with comparable tensile strength (550 ksi) and 90% of the tensile modulus of comparable industrial grade CF (29 Msi). The quoted fiber density (1.70g/cc) suggests that conversion has not fully completed (1.8 - 1.82 g/cc expected). Given these accomplishments, the reviewer believes that the technical work is sound; it is simply disappointing to the reviewer that the equipment failure has limited the opportunity to accomplish more trials and iterate the process/equipment design further. Initial reports of energy consumed is encouraging but incomplete for the same reasons as identified above.

Reviewer 4:

This reviewer noted that several milestones have been delayed. The approach to completing the project within the project timeframe is not clear to the reviewer.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

This reviewer found a good relationship between the partners especially related to capabilities.

Reviewer 2:

This reviewer considers that the only collaboration presented was with a tier 1 supplier of carbon fiber. Nothing was mentioned regarding collaboration with OEMs that would be producing the end product with the new CF material or with other national laboratories or universities.

Reviewer 3:

According to this reviewer, there should be no debate that the laboratory and industry collaboration resulted in the construction of a working prototype. This is found commendable and an important recognition. The shortfall here, according to the reviewer, is the loss of time and the limited accomplishments as a result of equipment failure. The reviewer asserts that a fully documented design failure mode and effects analysis and process failure mode and effects analysis are standard industrial practices aimed at identifying and mitigating risks associated with design and process activities such as this. The reviewer believes that the collaboration would be strengthened by this type of effort and, if not have prevented the failure, would have anticipated and provided a path to recover the milestone events.

Reviewer 4:

This reviewer complained that there was no mention of the role of 4XTechnology LLC in the presentation.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer found the cost analyses of the final product to be missing. Energy consumption analyses is great and in line with the goals, but he other part of the goal is the reduction of total CF cost, according to the reviewer.

Reviewer 2:

This reviewer believes that the team has put together a set of recommended future work that meets the objective and deliverables of the project. The reviewer finds this is commendable and will successfully complete the project. The present project is concluding within weeks, so the proposed future research is left for future funding. The reviewer's fundamental concerns are (1) whether the equipment failure that occurred has been fully understood with a root cause and a means to prevent or anticipate failure conditions and avoid them and (2) whether the HTC equipment and the process that it is expected to operate is robust and sustainable. The reviewer is unclear if the team plans to demonstrate this as it "implements all needed modification toward optimization of the HTC process."

Reviewer 3:

It is not very clear to this reviewer how the project will overcome the barriers associated with equipment deployment and complete the project on time.

Reviewer 4:

This reviewer noted that, although the project was scheduled to complete at the end of June 2023, the proposed future research was to complete the research to reduce electromagnetic energy reflection to improve the tuning of the system, complete the energy consumption evaluation, implement all needed modification towards optimization of the high-temperature conversion process, and conduct a computer simulation of optimized and final hardware arrangement using commercially-available software to validate the model. These were some of the tasks that were to be completed before the end of the project and will be difficult to complete.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer shared that the work contributes to a reduction in the cost of CF material which is used to reduce the weight and thus increase energy efficiency of vehicles.

Reviewer 2:

This reviewer finds that the project is relevant to supporting the overall VTO Materials subprogram objective to address significant technology gaps for lightweight structural materials like polymer composites.

Reviewer 3:

This reviewer pointed out that an explicitly stated goal of DOE's Materials research subprogram is to reduce the cost of vehicle lightweighting materials. The ability of CFRPs to both achieve up to a 60% reduction in structural weight and to perform in commercial transportation and consumer automotive applications is well documented. The overarching barrier is the cost of these materials. The present research program clearly aligns with this stated goal and, when scaled and applied by industry, will positively impact cost. Furthermore, the opportunity to expand throughput and improve capital utilization is significant for expanding the availability of fiber as well reducing CO_2 emissions per unit mass/volume of material manufactured.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This project was funded $3.5 million over a three-year period for one national laboratory. The resources are considered more than adequate to develop a CF that would overcome some of the technical barriers. The project's weaknesses were in the design of a prototype system that could not be made functional during the original project timeline.

Reviewer 2:

According to this reviewer, the team has met the objectives of the project and has suggested that resources provided were sufficient. The comment about the team related to specific gauges and monitoring equipment that failed to anticipate and warn about the potential hardware failure suggests that design details and the opportunity to expand funding to avoid such failures should become a gating element of future projects of similar complexity and scale. It is possible that an infusion of incremental funds to upscale the equipment may have been beneficial and reaped outcomes significantly greater than the incremental cost.

Reviewer 3:

This reviewer found that the information provided by the team is not adequate to determine if the remaining funds are sufficient to complete the work. Vital information is missing.

Presentation Number: MAT197
Presentation Title: Multi-Functional Smart Structures for Smart Vehicles
Principal Investigator: Patrick Blanchard (Ford Motor Company)

Presenter

Patrick Blanchard, Ford Motor Company

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

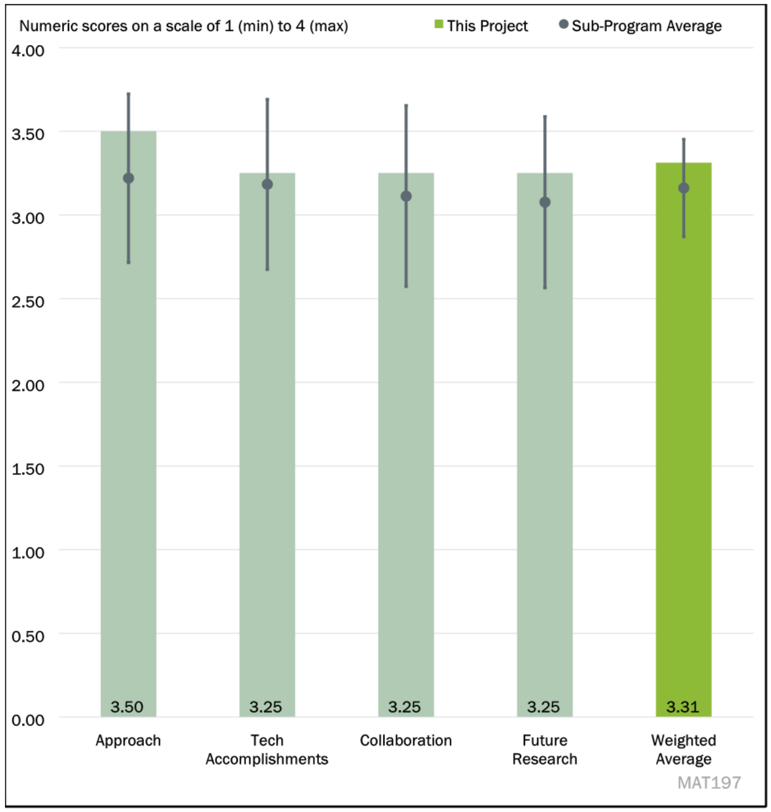

Figure 5-31 - Presentation Number: MAT197 Presentation Title: Multi-Functional Smart Structures for Smart Vehicles Principal Investigator: Patrick Blanchard (Ford Motor Company)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer finds the approach employed in the project to overcome technical barriers commendable. According to the reviewer, the project exhibits a well-designed structure, and the timeline appears reasonable. The strategic combination of high modulus and lower modulus materials offers an optimal solution in terms of material cost and weight. This concept has been effectively utilized in this project and expanded for high-volume manufacturing. Additionally, the project aims to explore new processing innovations for manufacturing hollow closed sections, which have extensive applications in the automotive industry. The reviewer believes that the incorporation of sensors and wiring within the composites to reduce costs is a brilliant idea. This approach enhances the attractiveness of composites as potential candidates for various applications.

Reviewer 2:

This reviewer observed that the key barriers are to make the structure lightweight and add functionality without compromising structural integrity. Several technical aspects were successfully addressed through the concept technology being investigated including weight, cost, and functionalization potential (relative to the baseline). A remaining barrier is mass saving.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

Regarding the business case, it is unclear to the reviewer why a parallel study was not conducted by Yanfeg, one of the team members and a tier 1 supplier. Such a study would have added valuable insight due to Yanfeg's extensive experience, making it a more realistic assessment. The utilization of material characterization for the proposed anisotropic material in simulations was not clearly explained to the reviewer's satisfaction. The reviewer suggests that it would be helpful to understand how this characterization was incorporated and utilized in the simulation process. The validation process for the small-scale demonstrator molding exercise remains unclear. The reviewer states that it would be beneficial to provide details on how the control of wall thickness was achieved in the water-assisted injection molding process. Additionally, information regarding the specific process variables used for both the small-scale and mid-scale demonstrators would be helpful to the reviewer, who asks whether any simulations were conducted to optimize the process parameters. Sensor integration was mentioned, but the reviewer is not sure what kind of sensor and how the integration was tested and validated was not provided.

Reviewer 2:

The reviewer reports that the team is on track to complete the tooling to make full-size demonstrator parts.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

This reviewer believes that the project demonstrates strong collaboration among the team members.

Reviewer 2:

This reviewer noted that the collaboration appears to involve all partners, who work collaboratively.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The remaining tasks make sense to this reviewer as described toward completing the project in the next six months.

Reviewer 2:

On Slide 18, it was mentioned that additive manufactured attachment features are no longer viable due to cost constraints. However, the available alternative path for the project, such as incorporating new tooling, was not specified.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer believes that the project holds significant relevance in the field of advanced materials, particularly in supporting the automotive industry's lightweighting requirements.

Reviewer 2:

The project is relevant for VTO Materials program objectives, in the view of the reviewer.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer stated that the project possesses an adequate amount of resources necessary for its execution.

Reviewer 2:

According to this reviewer, the resources are sufficient as described.

Presentation Number: MAT198
Presentation Title: Development of Tailored Fiber Placement, Multi-Functional, High-Performance Composite Material Systems for High Volume Manufacture of Structural Battery Enclosure
Principal Investigator: Venkat Aitharaju (General Motors Company)

Presenter

Venkat Aitharaju, General Motors Company

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

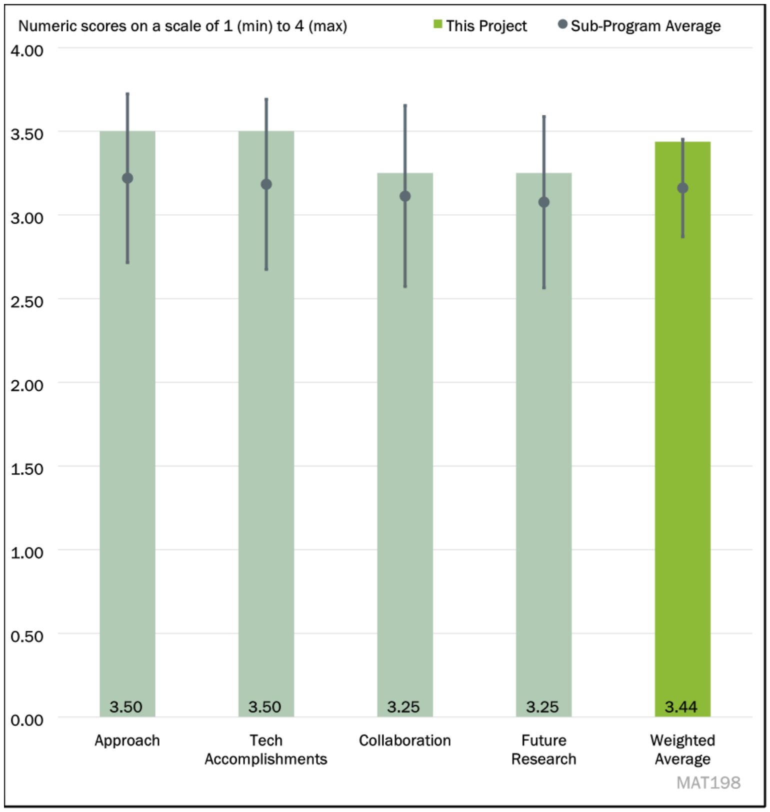

Figure 5-32 - Presentation Number: MAT198 Presentation Title: Development of Tailored Fiber Placement, Multi-Functional, High-Performance Composite Material Systems for High Volume Manufacture of Structural Battery Enclosure Principal Investigator: Venkat Aitharaju (General Motors Company)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer reports that the team has presented a comprehensive and impressive set of tools to address the design challenges associated with fiber reinforced polymers. The team has been innovative and considered glass/carbon hybrid materials to reduce the brittle nature of fracture and addressed computational challenges with reduced models applying ML techniques to inform a neural network approach for predicting behavior. These tools have been validated using relatively simple geometries and address behaviors that are challenging to model (such as resin fill and resin transfer processes).

Reviewer 2:

This reviewer determined that the project addresses a critical issue in the automotive industry in making composite battery enclosures. The approach and timeline are reasonable to the reviewer. A significant effort was made to the hybrid fiber approach. Still, the reviewer found no clear indication of cost savings provided, believing that hybrid tow manufacturing will also cost more than the one fiber tow type.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The research team has done what this reviewer considers a superb job in developing effective models for material performance prediction. The demonstrated use of carbon/glass hybrids to improve ductility and enhance lifetime performance is commended by the reviewer. Process modeling using ML and artificial intelligence (AI) methods to predict mold filling is well done and should drive a successful full-scale demonstration at the stated cycle time goal (3 min). Resistance measurement methods for simple harmonic motion has been implemented well and provides a relatively simple/reliable approach. The reviewer offers only one possible negative comment: There is a lack of specific defined methods or elements of a comprehensive techno-economic model to identify the projected weight savings (over a presumed baseline) and the incremental cost of the composite battery enclosure (to determine the cost per lb. of weight saved). To the extent that such cost/performance modeling can inform decisions related to material selection as well as product and process design for optimizing this parameter, the modeling should be underway presently.

Reviewer 2:

The project seems to this reviewer to be on schedule, with all the milestones having been met, while demonstrating many technical accomplishments. A full-scale battery enclosure is planned, and a tool design is underway. The project will be finished in time as long as the team receives everything on time.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

According to this reviewer, the team is an extensive and multidisciplinary one to conduct this program. Additionally, the expertise of each partner is identified. It became a bit less clear which specific activities were led by each partner, but the level of work accomplished, and the technical detail suggests to the reviewer broad participation. A detailed responsible, accountable, supportive, informed and consulted table could always be included to provide a clearer picture of those roles and responsibilities. But the reviewer found that, regardless of such omission, coordination appears good because the project presentation suggests a seamless integration of the multidisciplinary activities.

Reviewer 2:

The project has many partners, but from the presentation, the work scope for each partner was not clear to this reviewer. Slide 20 mentioned mostly the expertise of each partner but their tangible contribution was not clear to the reviewer.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer feels that the project is moving in the right direction, and the future tasks align well with the technical barriers the team is trying to overcome.

Reviewer 2:

The reviewer comments that the team has provided a reasonably comprehensive set of remaining tasks for project completion. There is not a reference to what activities might be needed to commercialize the resulting battery enclosure and additional comments related to the development of a comprehensive techno-economic model would be appreciated by the reviewer. There remains little reference (other than passing reference to use of phenolic matrix materials and intumescent coatings) to meeting the fire requirements that are necessary for these enclosures, nor strategies to mitigate EMI from the internal batteries, such as a plan for fire testing of materials or structures tied to this project.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

There can be no doubt to this reviewer that this project is relevant to the VTO Materials subprogram objectives. Lightweight battery enclosures will require the highly specific material properties offered by reinforced polymers. This project addresses many of the challenges related to commercializing this application. Material hybridization, process modeling and monitoring, as well as structural health monitoring to ensure passenger safety, will enable the transition and adoption of these materials.

Reviewer 2:

The reviewer notes that the project aims to design, develop and manufacture composite battery enclosures. These enclosures are some of the most significant parts in EVs, and their weight optimization is critical for the overall vehicle's weight reduction. Therefore, this project is well aligned with the VTO's overall objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

To this reviewer, on the face of it, this is a very large (and expensive) program; however, given the scope of the work and the extensive research necessary across the large number of disciplines, it appears to be both adequate and necessary. The team has done a good job managing a large cadre of collaborators and integrating the technologies to meet the project objectives. The only glaring omission is specific work on the techno-economic model necessary to assess the value proposition of lightweighting the battery enclosure. This reviewer hopes useful insight related to the capital expenditures, bill of materials, and labor content of the enclosure will be modeled to identify the economic challenges associated with meeting capacity and technical requirements.

Reviewer 2:

The reviewer believes that the project is appropriately funded, and that the resources are sufficient to achieve the project's goals in the stipulated time.

Presentation Number: MAT199
Presentation Title: Ultra-Lightweight Thermoplastic Polymer/Polymer Fiber Composites for Vehicles (Inter-Lab Project)
Principal Investigator: Kevin Simmons (Pacific Northwest National Laboratory)

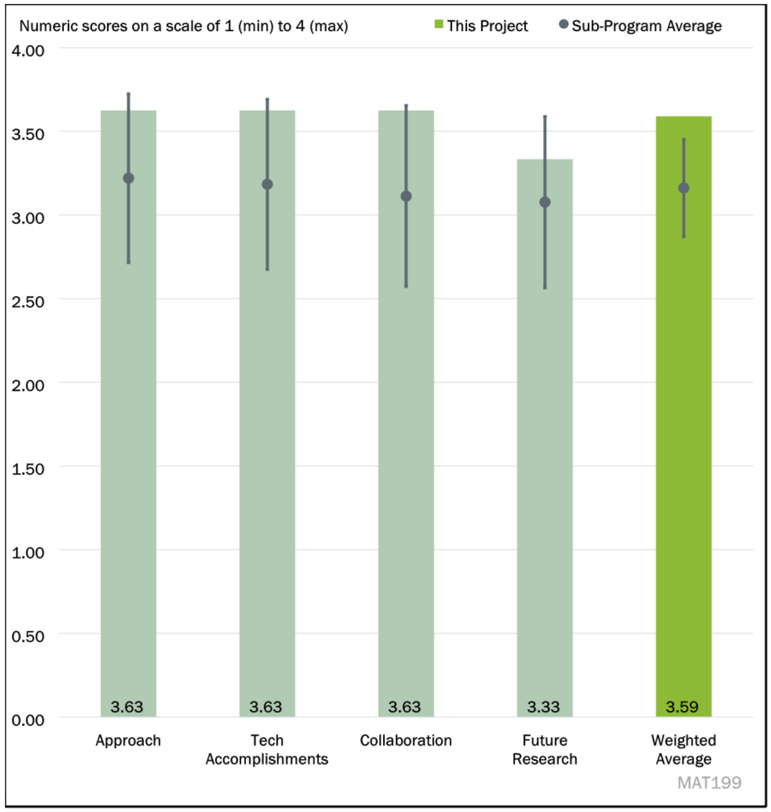

Figure 5-33 - Presentation Number: MAT199 Presentation Title: Ultra-Lightweight Thermoplastic Polymer/Polymer Fiber Composites for Vehicles (Inter-Lab Project) Principal Investigator: Kevin Simmons (Pacific Northwest National Laboratory)

Presenter

Kevin Simmons, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 25% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer identified the barriers described by the team as the lack of infrastructure for producing lightweight, high-strength materials such as CF composites using low-cost, high-volume manufacturing to produce low-cost CFs with some level of recyclability. Targets included a minimum of 50% cost reduction in materials during manufacture, high toughness for impact performance without loss of strength, infinite shelf-life, excellent environmental safety and health, consistent processing performance, and recyclability. The approach presented was to determine the material system, process parameters, and the modifications to the individual components needed to meet the technical goals for the project. This approach clearly addresses these barriers, according to the reviewer. This project is the final phase of an overall effort that started in 2020, so the timeline was reasonably planned for a four-year R&D period that will culminate in the delivery of a composite system with more than 500 megapascals (MPa) strength, 10 gigapascals (GPa) modulus, and 5% elongation at break.

Reviewer 2:

This reviewer approves that PNNL and ORNL are teamed up to address the technical barriers in lightweight low-cost composites. The team uses low-cost polymer fibers (polypropylene [PP] fibers) to reinforce polymer matrices. This is a smart, alternative approach to CF polymer composites. The results are encouraging; the composites exhibit comparable or even better properties than the expensive CF composites.

Reviewer 3:

This reviewer finds the approach of developing methods to use alternative fibers in composites exciting for the vehicle industry both for reducing the cost of composites and for enhancing their performance, especially in a shift towards EVs. This work cleverly focuses on manufacturing methods for realizing polyolefin-based composites for both strength, ductility, and re-use. The potential work for re-using material is focusing on thermal/mechanical recycling, which is a very de-carbonized approach. The approach could be strengthened by a focus on recycling and the inclusion of analysis to guide activities. Blended composites of polyethylene (PE) and PP are incompatible and thus additives will need to be used in multiple lives of the material. The reviewer suggests that better documentation on the "multiple life" strategy would be beneficial.

Reviewer 4:

This reviewer found that the project is reasonably well scoped and executed but with somewhat inconsistent objectives. For example, the objectives section shows plans to "develop a low cost, high performance thermoplastic polymer-matrix/polymer-fiber composite system… ." However, throughout the presentation, a wide variety of systems are described and evaluated with PP and ultra-high molecular weight PE (UHMWPE) fibers, in woven and unidirectional forms, and with high density PE, PP, and low-density PE matrices, over a wide range of fiber fractions manufactured with a wide range of processes including both continuous and discontinuous reinforcement. The comparative systems were varied as well but had no real cost comparisons. The team did mention during the presentation that the overall goals were more to point out a variety of different ways these composite systems might compete with incumbent systems and the results are fairly interesting and useful, and largely fulfill that objective.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer found that the technical accomplishments were consistent with the project plan and timeline, with all project milestones being met during the development period. Fiber length retention of more than 50% after injection molding was achieved, and the process temperature was determined to be a critical process parameter because fiber melting and shrinkage increased above a specific temperature and injection difficulties increased below a specific temperature. A composite system with 420 MPa strength and 20 GPa modulus was achieved by using ultra-high molecular weight PE fiber. The strength was slightly less than the target of 500 MPa but the modulus was double the target of 10 GPa. The PE fiber outperformed available CFRPs by greater than 26% for one -time impact, greater than 500% for repeated low impact, and 30% recovered by healing after impact, which addresses the target of high toughness for impact performance without loss of strength. Four processes were developed that demonstrated material integrity for recycled composites from chopped or reground virgin composites – three were injection molding and one was compression molding. The reviewer sees the project on track to demonstrate the mechanical properties of the recycled materials. One of the processes demonstrated that a thermoplastic fiber/thermoplastic matrix compression molding compound retains 50% of the original fiber length, which is significant for zero fiber attrition. These technical accomplishments addressed the targets of consistent processing performance and recyclability. The project is also on track, according to the reviewer, to demonstrate a composite system that will meet all requirements for 500MPa strength, 10GPa modulus, and more than 5% failure strain.

Reviewer 2:

The composites from PP/PE and PP/PP injection molding show results encouraging to this reviewer. The team also demonstrated a low cost, low carbon footprint recycling route. The process can be simply inserted into the existing injection molding lines without re-investing in equipment. This, the reviewer believes, will help secure supply chains and reduce carbon footprint.

Reviewer 3:

The approach is well laid out and the achievements are well documented. Interestingly, and impressive, is the enhanced performance relative to CF reinforced composites (CFRCs) across many impacts, The project team should consider also comparing performance to that of the material being replaced, steel or Al.

Reviewer 4:

Although the objectives are not totally clear to this reviewer, the reviewer finds a lot of interesting data presented which have been developed in this project and support different ways that thermoplastic fiber and resin composite systems might be utilized to address varying requirements, especially where recycling is a high priority.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1: .

This reviewer lauded the collaboration and coordination between ORNL and PNNL on this project as outstanding. PNNL performed the characterization and matrix interaction for the commercially-available fibers, determined the key panel processing parameters and recycling process, and developed the process for the fiber surface modification. ORNL performed the fiber development that resulted in minimal shrinkage, optimized strength, and provided the composite material to PNNL for additional studies. ORNL also performed the thermal analysis, mechanical evaluation, morphology evaluation, and comparison with commercial fibers from PNNL. Since this is early-stage material development, there was no collaboration with industry, academia, or other external entities.

Reviewer 2:

This reviewer noted that PNNL and ORNL have complementary expertise. The collaboration has been excellent. The project is on track and will be a high TRL for transferring to industry.

Reviewer 3:

PNNL and ORNL collaboration appears to this reviewer to be quite good, taking advantage of the specific unique capabilities in each laboratory. Composite data produced by PNNL mixes a wide variety of approaches, as mentioned above. Although ORNL has excellent fiber development expertise and has produced significant accomplishments with demonstrating UHMWPE fiber, it is not clear to the reviewer what the objectives are for the UHMWPE fiber and how this fiber would be differentiated from those similar commercially-available fibers that are less costly, enhanced performance, etc.

Reviewer 4:

This reviewer observed that the project team provided notes on how the project is integrated and a collaboration between ORNL and PNNL. The reviewer suggests that the work could be strengthened with a larger industrial component or technical advisory.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer observes that the project will complete all milestones in Fiscal Year 2023. The team will work on recyclability, which is important in terms of securing supply chains and reducing carbon footprint.

Reviewer 2:

This reviewer points out that, since this project will complete at the end of September 2023, the project is basically completed. The proposed future work is completion of the original milestones for this project.

Reviewer 3:

This reviewer notes that the future of the work focuses on recycling approaches. Therefore, it seems to the reviewer that more time may be needed to further understand recycling of the composites, especially regarding issues that may arise. The recycling approach could be a main focus point of work beyond this initial 3-year Annual Operating Plan.

Reviewer 4:

This reviewer finds that the approach does illuminate potential advantages of various thermoplastic systems as usually assumed but does not clearly demonstrate the pathway to specific automotive applications.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer finds that the objective of this project was to develop a low-cost high-performance thermoplastic polymer, polymer-matrix/polymer-fiber composite system with specific mechanical properties comparable to traditional composite systems, 30% lighter than traditional composite systems, low material cost, a short (3 minutes or less) process cycle time, and recyclability. This project addresses VTO goals to develop lightweight materials that addresses significant technology gaps for structural materials such as polymer composites. Technology gaps addressed by this project include formability, manufacturing cycle time, incorporation of new materials into manufacturing processes, and recyclability.

Reviewer 2:

It is clear to this reviewer that the polymer-polymer composite approach addresses many of the VTO barriers such as less than $5/kg-mass saved, low-cost fibers, and durability.

Reviewer 3:

According to this reviewer, lightweight, low-cost polymer composites are essential for lighter and smarter EVs. The polymer fiber/polymer matrix composites by injection molding is a smart alternative to CF polymer composites. The team has demonstrated high TRL which directly supports the VTO objectives.

Reviewer 4:

This reviewer states that the project focuses on broad vehicular goals such as recycling and lightweighting but indicates what still needs to be done to achieve commercial relevance.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer notes that the project was funded $750,000 in Fiscal Year 2023 for two national laboratories to perform fundamental R&D on composite materials. Both laboratories have superb materials development and characterization capabilities, so the resources are considered very effective for overcoming most barriers described.

Reviewer 2:

The project seems to this reviewer to be well funded for the objectives described.

Reviewer 3:

The team seems to this reviewer to have the right amount of resources.

Reviewer 4:

According to this reviewer, PNNL and ORNL have the resources required for the project. The project is on track and will complete all milestones in a timely fashion.

Presentation Number: MAT200
Presentation Title: Additive Manufacturing for Property Optimization for Automotive Applications
Principal Investigator: Seokpum Kim (Oak Ridge National Laboratory)

Presenter

Seokpum Kim, Oak Ridge National Laboratory

Reviewer Sample Size

A total of six reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

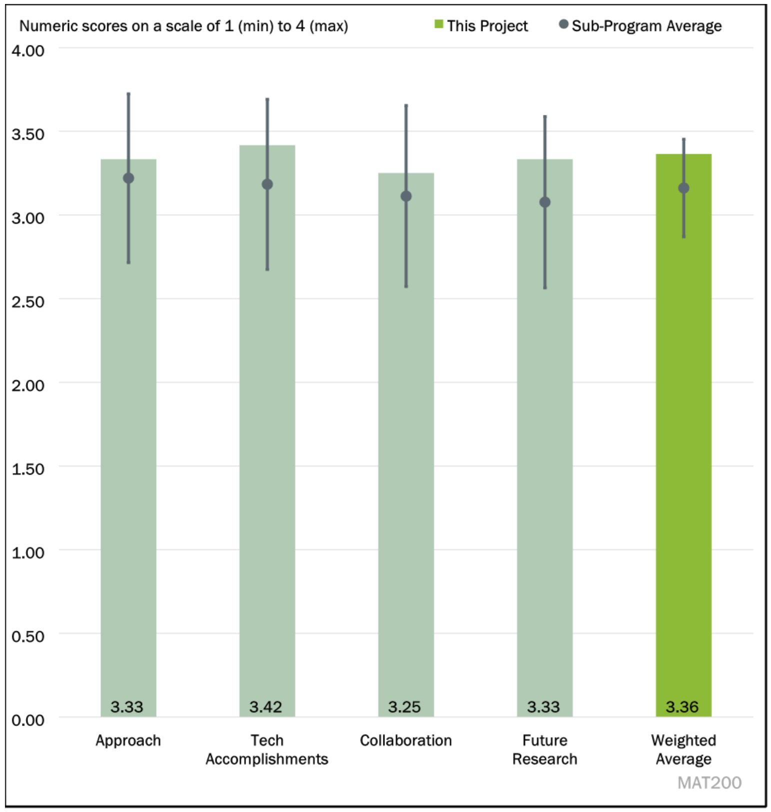

Figure 5-34 - Presentation Number: MAT200 Presentation Title: Additive Manufacturing for Property Optimization for Automotive Applications Principal Investigator: Seokpum Kim (Oak Ridge National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer considers the project design to be concise and logically planned without excess.

Reviewer 2:

This reviewer praises the additive manufacturing of lattice structures with less and lightweight materials as a smart approach. The printed lattice architectures exhibit an exceptional combination of mechanical properties that are superior to the traditional solid materials/structures. The additively manufactured lattice structures are designable based on the stress and function requirements. This is considered by the reviewer to be an alternative way to reduce weight and realize multifunctionalities.

Reviewer 3:

This reviewer reports that the combined modeling and experimental approach is great and very useful during the performance of the work, but the baseline to compare to the design either is not presented nor clear. One of the goals of the project is reducing costs. There should be a techno-economic analysis/life cycle analysis (TEA/LCA) performed on the approach to indicate that the concept is economically viable at optimal printing speeds and reduced material costs.

Reviewer 4:

This reviewer believes that the approach and work plan are fine but has a primary concern that the apparent poor quality of the 3D printed structure may compromise the actual test results. Another method to develop the ML/AI training is to use the 3DSystems with the process shown on Slide 4, where material modulus can be controlled layer by layer and print results are very high quality.

Reviewer 5:

The technical approach is considered sound overall by this reviewer. A lingering concern of the reviewer is the cost of the process and whether it is compatible with mass-market vehicle manufacturing.

Reviewer 6:

This reviewer called for more details on the relevance of the project, especially the selected 2.5D cellular structure manufacturing via AM would be good for contextualizing the work, especially the need for such parts in vehicles and current barriers that prevent their easy development.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer pointed out that ORNL, teamed up with Ford and University of California-Berkeley, has simulated, designed, and optimized 2.5D cellular structures, and manufactured them with extrusion-based AM. The incorporation of ML techniques in lattice design enables selective design and manufacturing based on the stress and function needs for auto-structures.

Reviewer 2:

The reviewer praised the progress as being very good on the three main tasks.

Reviewer 3:

This reviewer considers that great strides have been made in adopting ML and computational approaches for AM part and process design.

Reviewer 4:

This reviewer remarked that there had been good technical accomplishments but that some of the printed objects appear to not be homogeneous, raising the question of whether the material properties are consistent across the part enough to prevent failure points.

Reviewer 5:

This reviewer commended the team on having made significant progress in the modeling, optimization and demonstration of lightweighted structures with effective use of computer design tools. The choice of printed materials may not, however, meet final application requirements, according to the reviewer.

Reviewer 6:

This reviewer recounted how lattice designs were evaluated and fabricated using big area additive manufacturing (BAAM). The structures were tested for static and dynamic performance. The reviewer’s primary concern is that the armrest structure looks to have many flaws and poor quality, making test results suspect. The reviewer suggests repeated testing just below ultimate failure to see if there is progressive damage during the test which would alter desired test results. More precise extrusion equipment should yield better results than BAAM.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

This reviewer feels that the collaboration has been great. ORNL has been collaborating with the University of California-Berkeley and Ford, utilizing the complementary expertise in design, simulation, ML and experimental. Such collaboration accelerates the progress and TRL for technology transfer to industry.

Reviewer 2:

It looks to this reviewer as if the team has good collaboration with Ford and University of California-Berkeley.

Reviewer 3:

It seems to this reviewer that the team is well integrated at least in relation to how the tasks were split amongst the three main entities.

Reviewer 4:

This reviewer noted a great discussion on how the partners collaborate.

Reviewer 5:

The reviewer noted there was sufficient collaboration.

Reviewer 6:

This reviewer found the ORNL/Ford/University of California-Berkeley collaboration satisfactory but another national laboratory in additional to ORNL may have given additional benefit/perspective.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer determined that the project team has a solid pan for identifying suitable CF/acrylonitrile butadiene styrene (ABS) – thermoplastic polyurethane blends for bumper design and manufacturing. In addition, the team will realize full-scale printing of a performance-optimized multi-material lattice structure frontal bumper by pursuing ML. The milestones for 2023 are achievable.

Reviewer 2:

This reviewer found that the plan is well developed and clear with a good chance of meeting proposed goals.

Reviewer 3:

This reviewer commented that the project is nearly completed with a few milestones left for demonstration.

Reviewer 4:

The proposed work to be conducted is, to this reviewer, reasonable but details on the TEA of the armrest designs would have been useful.

Reviewer 5:

According to this reviewer, the proposed future work should include a cost analysis that would compare this technology to current designs.

Reviewer 6:

This reviewer believes that the objective for using AI to develop an optimized lattice structure based on desired structural performance is valuable, but a better approach would have been to develop and demonstrate this approach first on a simpler and higher resolution material system and printing method. The relatively poor quality of the BAAM structures seems to compromise the approach at this stage of development, according to the reviewer.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The project is considered relevant to lightweighting, but costs could be an issue according to this reviewer.

Reviewer 2:

This reviewer believes that the project is relevant to lightweighting of automotive sub-components using AM technologies.

Reviewer 3:

This reviewer confirms that the project supports VTO Materials subprogram goals for lightweighting vehicle structures. The development of an AI design tool that can take advantage of emergent materials and manufacturing methods is desirable. The reviewer believes that the lattice structures under evaluation would benefit from a higher resolution fabrication method with more test samples fabricated and evaluated to develop the training set.

Reviewer 4:

This reviewer sees the project as relevant to VTO Materials subprogram overall mission.

Reviewer 5:

This reviewer believes that lightweight, high-performance bumpers are critical for lighter and smarter EVs and that the project directly supports these VTO Materials subprogram objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer stated that the resources are sufficient.

Reviewer 2:

This reviewer finds the resources sufficient to meet the goals without excess.

Reviewer 3:

The resources appear to this reviewer to be sufficient.

Reviewer 4:

This reviewer considers that the project team has the resources required for accomplishing the project milestones that will be ready for scale-up and transfer to industry via the industry partner, Ford.

Reviewer 5:

This reviewer thinks the resources are sufficient if a simpler starting approach was pursued as indicated in prior comments.

Presentation Number: MAT201
Presentation Title: Additively Manufactured, Lightweight, Low-Cost Composite Vessels for Compressed Natural Gas Fuel Storage
Principal Investigator: James Lewicki (Lawrence Livermore National Laboratory)

Presenter

James Lewicki, Lawrence Livermore National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

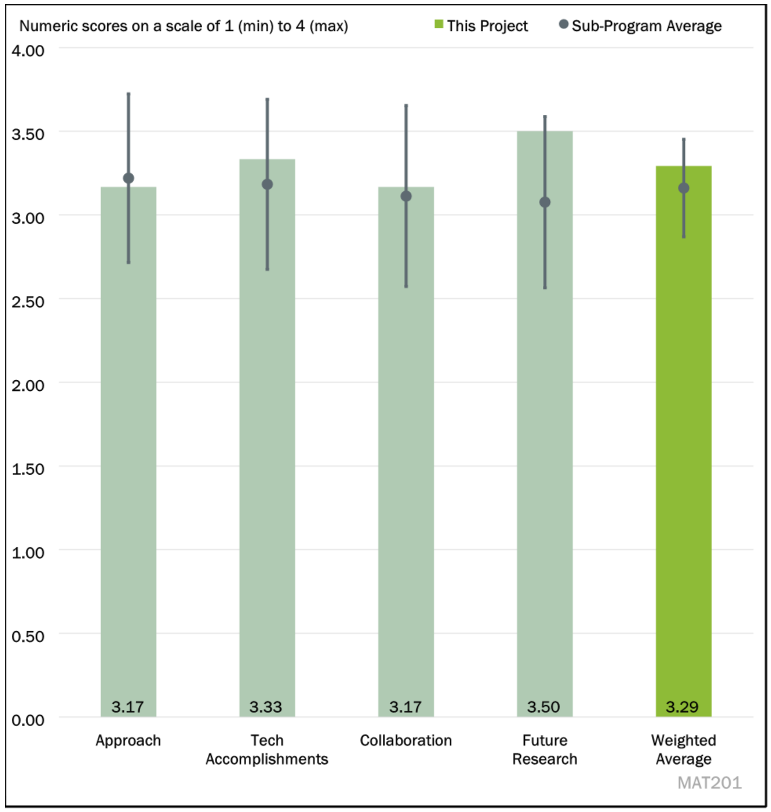

Figure 5-35 - Presentation Number: MAT201 Presentation Title: Additively Manufactured, Lightweight, Low-Cost Composite Vessels for Compressed Natural Gas Fuel Storage Principal Investigator: James Lewicki (Lawrence Livermore National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer pointed out that the project used three types of nanofillers to reinforce resin. The team designed and implemented hybrid long-fiber deposition hardware and realized a unique hybrid print head for composite manufacture. The ‘liner zone’ exhibits high tensile strength structural midzone with enhanced toughness/impact resistance in the outer layers. The initial models suggested 20% fiber reduction, which the reviewer finds very encouraging as an alternative way discovered by the team for reducing the cost.

Reviewer 2:

This reviewer finds the equipment design and research exciting while raising questions such as how the performance compares to a current commercially-produced CF tank and whether the CF baseline is sufficient. The reviewer believes that there needs to be a cost analysis for the approach but that the project otherwise shows very good progress.

Reviewer 3:

This reviewer asserts that the development of 3D printing using CF and ultraviolet light to cure the resin may have some merit and, in fact, is a commercial technology used by several companies, but that the application of this approach to a pressure vessel is misplaced due to the very high-performance requirements. The graded structure may have some relevance in other applications, but its value is not apparent for this application.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer commends the fact that the project team found it possible to use less CFs and reduce the cost using a rationally optimal design. The team manufactured two-inch composite cylinders and achieved a direct ink write toolpath optimization via rigid body dynamics. They improved manufacturability using digital twin approaches. The modular tank manufacturing strategy/task is well planned. The team may further optimize nanofiller dispersion to maximize reinforcing effects.

Reviewer 2:

This reviewer found that technical accomplishments are moving in the right direction. There would need to be future research to verify the validity of the approach.

Reviewer 3:

The team fabricated some structures with its approach, but the process is years behind the industry state of the art according to this reviewer who provided continuous composites as one example.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

This reviewer applauds that the collaboration between LLNL, Materials Sciences LLC, the University of Texas High Resolution X Ray Computed Tomography Facility, and Aerojet RocketDyne has been going well. The project is on track and the remaining milestones are achievable, according to the reviewer.

Reviewer 2:

This reviewer believes that the collaborative efforts are sufficient.

Reviewer 3:

This reviewer notes that the team partners provide technical support but suggests inclusion of a tank manufacturer. The project process is far too slow to be used commercially, according to the reviewer, and the ultraviolet cure resins performance is much worse than state-of-the-art toughened epoxy resins used today. The approach may have value for conformal or complex structural shapes.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer commented that the team will make test prints and further improve the nanomaterials resin, suggesting that the project team may look at the nanofiller dispersion and loading to achieve even higher reinforcing effects.

Reviewer 2:

This reviewer had no comment because the project is ending.

Reviewer 3:

This reviewer observed that the project is near completion.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer affirmed that the project is relevant to natural gas transportation but believes that a cost analysis is needed.

Reviewer 2:

This reviewer commented that compressed natural gas (CNG) tanks are critical to the reduction of CO_2 emissions for vehicles. The project plan was to find an alternative way to developing low cost, lightweight CNG tanks, which the reviewer believes directly supports VTO Materials subprogram objectives and secures supply chains.

Reviewer 3:

This reviewer said that the project would be better applied to other complex structures such as project MAT200 (lattice structures). The approach is much too slow and performance too poor for a conventional pressure vessel.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer described how the project leverages the resources and expertise of LLNL, Materials Sciences LLC, The University of Texas High Resolution X-ray Computer Tomography Facility, and Aerojet RocketDyne. The 3-pronged approach leveraging AM, design optimization and nanomaterial modification in a graded, single process enables a high performance CNG tank cheaper to manufacture from less expensive feedstocks, according to the reviewer.

Reviewer 2:

This reviewer found the resources are sufficient.

Reviewer 3:

This reviewer opined that the resources are fine for Objectives 1 and 2, but for Objective 3, the pressure vessel was probably not the best choice for project demonstration. The technology may apply better to topology optimized grid formation on a thin shell structure.

Presentation Number: MAT202
Presentation Title: 3D Printed Hybrid Composite Materials with Sensing Capability for Advanced Vehicles
Principal Investigator: Rigoberto Advincula (Oak Ridge National Laboratory)

Presenter

Rigoberto Advincula, Oak Ridge National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

67% of reviewers felt that the project was relevant to current DOE objectives, 33% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

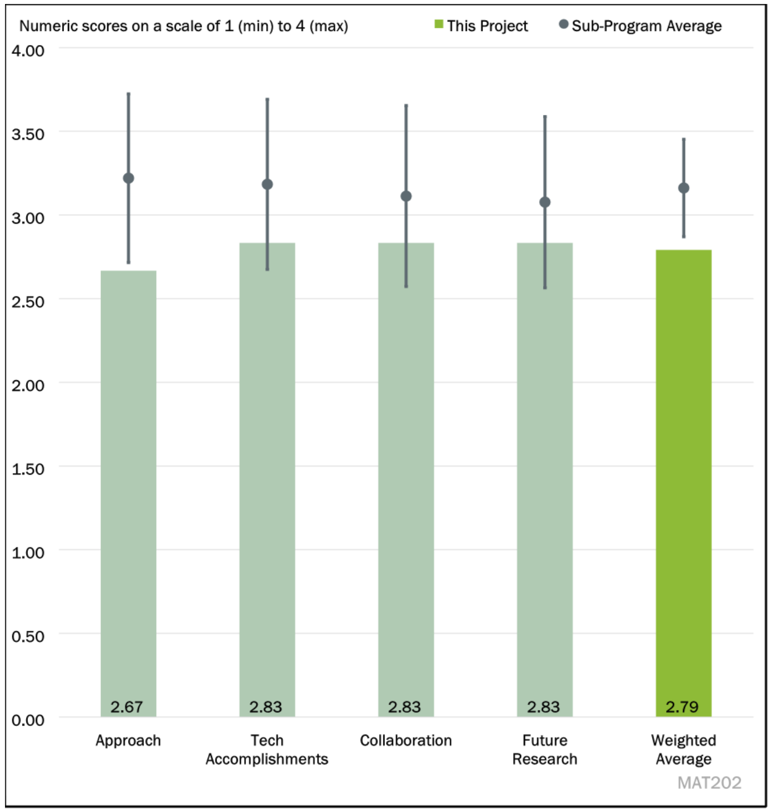

Figure 5-36 - Presentation Number: MAT202 Presentation Title: 3D Printed Hybrid Composite Materials with Sensing Capability for Advanced Vehicles Principal Investigator: Rigoberto Advincula (Oak Ridge National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer commended the project for having targeted technical barriers that were clearly addressed and that project was well-designed. The presentation clearly divided the project into four tasks to improve interfacial adhesion, perform computational modeling, and design 3D-printed parts with integrated sensing. With this being the third and final year of this project, the reviewer finds that the timeline is reasonable to overcome the remaining technical barriers.

Reviewer 2:

According to this reviewer, the team has done a good job of articulating the progress across the four tasks and the reasons for delaying one of the tasks until Q3 Fiscal Year 2023. Results presented indicated that the project on the right path to overcoming barriers in the four main tasks, namely (1) precise chemical reaction control; (2) computation interface interaction; (3) 3D printing CF polymer composites; and (4) embedded sensor composite printing. The reviewer offered some general observations with a note that the slides are “not numbered” which the reviewer would have found helpful. (Note: the slides are numbered at the lower left of each slide which was probably difficult to read by the reviewer) Also, for the Task 1 objective to develop CF/polymer with enhanced inorganic-organic interface covalent interaction, the chemical structures/reactions shown are so small they are hardly readable by the reviewer. Hence, it was not possible for the reviewer to assess the specific approach used. The reviewer is not clear about the inorganic-organic interface and says that it would help to illustrate/clarify the figure captions and what they are conveying. They are obviously important results but remain largely unreadable. The reviewer had a similar comment regarding Slide 8 because it was unclear what the variants are that the bar graph is trying to compare. Figure captions are inadequate or non-existent. Task 3 is interesting in terms of co-extrusion to the reviewer but raises questions regarding the stability, repeatability, and scalability of the process. The reviewer notes that, presently, it is syringe scale, which is understandable, but the scaling would be important to practical applications. The reviewer raises the same question on Task 4, and that is how fragile or robust are the printed sensors and anode. The presentation shows an automotive example, but not the gap is between the present work and what is needed, according to the reviewer.

Reviewer 3:

This reviewer is concerned that the project appears to be focused on a complex (and unlikely to succeed) means of developing embedded sensing /and or a nebulous means of advancing AM composites technology in general. The technology is unlikely to serve advanced, scaled composites for automotive applications in its present form. The project appears to significantly weigh the development of chopped fiber and continuous fiber 3D thermoset printing; however, the development of these technologies for the stated goals seems excessive/unnecessary. These technology developments are also currently available at a higher TRL/MRL within other research organizations in the United States. This reviewer therefore questions the relevance of developing these technologies in parallel under this program rather than pursuing collaboration with other research and technology groups directly.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer considers that the team met the outlined milestones. Good results were presented for the fiber functionalization work. The reviewer did voice a concern with the acid treatment shown in Slide 8 where the surface roughness was increased significantly. That level of acid etching could reduce the fiber's mechanical strength, so the researchers need to be careful not to etch the fibers too much during chemical treatment. If there is follow-on work for this project that warrants another AMR presentation, the reviewer suggests that it would be good to show the mechanical loading curves that correspond to the voltage and current outputs from the polyvinylidene fluoride (PVDF) on Slide 13. The reviewer would like to see how well the electrical responses correspond to the mechanical inputs, specifically, whether the input mechanical force and output electrical response waveforms match and how repeatable they are over longer cycle times.

Reviewer 2:

This reviewer notes that some earlier comments are relevant to this section, as well. The team has proposed 4 main tasks: (1) precise chemical reaction control; (2) computation interface interaction; (3) 3D printing of CF polymer composites; and (4) embedded sensor composite printing. The reviewer offers some general observations with a note that the slides are "not numbered" that would have been helpful-For Task 1, develop CF/polymer with enhanced inorganic-organic interface covalent interaction; The chemical structures/reactions shown are so small they are hardly readable for this reviewer. Hence, it was not possible to assess the specific approach used. The reviewer is not clear about the inorganic-organic interface. It would help to illustrate/clarify the figure captions and what they are conveying. They are obviously important results but remain largely unreadable. The reviewer offered the same comment regarding Slide 8, questioning what are the variants that the bar graph is trying to compare. Figure captions are inadequate or non-existent. Task 3 is interesting in terms of co-extrusion but raises the question of how stable, repeatable, and scalable the process is. Presently it is syringe scale, which is understandable, but the scaling would be important to practical applications. The reviewer raises the same question on Task 4: How fragile or robust are the printed sensors/anode. The team shows an automotive example, but not the gap between the present work and what is currently in use. The team mentions around a 10x enhancement of piezoelectric output for a shear stress of 8% MoS_2 PVDF. This is impressive to the reviewer, but the question on scaling must be addressed/briefed to show practical significance.

Reviewer 3:

This reviewer sees little tangible progress having been made in the technology development required to meet goals.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

This reviewer praises good, effective collaboration with the University of North Texas (UNT) to perform the modeling and sensor characterization, and a great partnership with Hyrel to develop the continuous fiber extrusion in the 3D printer. The project overcame the challenges with that printer by improving on the original design, and it seems that the system is working very well now. The reviewer looks forward to seeing how well this technology is received by commercial partners for further integration into automotive applications.

Reviewer 2:

This reviewer observes that, on Slide 16, the presenter describes the distribution of work between UNT and ORNL. If this project is progressing as planned, it can be inferred that there is good collaboration between the researchers on both sides. Some more concrete exchanges in terms of students/post-docs and more specifics would have been useful to the reviewer. It seems to the reviewer that the presentation is almost like "everything is great," but the actual collaboration is difficult to assess.

Reviewer 3:

The reviewer recounted how the team described collaboration of ORNL with a UNT subcontractor. The reviewer believes that another national laboratory and an industry partner would greatly benefit the effort. Other national laboratories, for example, have significantly more advanced continuous CF thermoset printing capabilities. With proper collaboration, this project could have been enhanced rather than attempting to recreate a similar technology in the same funding stream.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer is satisfied that the team outlines reasonable remaining future work that should be achievable by the end of Fiscal Year 2023 when the project is expected to end. A cost estimate for the developed materials would be good to show to evaluate the feasibility of commercialization for this work. Additional studies on the poling effects on the PVDF would be good to show. The reviewer notes that the future of demonstrating 3D printing for larger structures with optimized formulations is a little vague, including the size of the structures planned to be printed and whether they will be economical to produce for vehicle applications.

Reviewer 2:

The reviewer noted the proposed future work follows their current work, calling out the following specific aspects. They felt demonstrating optimized continues CF–epoxy 3D printing into larger structures with optimized formations was a fairly general statement. The reviewer asks what are the target scales, which is important in terms of how far this research will get towards TRL 4-7. They also ask what is meant by optimized? This representation is somewhat vague and suggests clearly laying out where are the organic-inorganic interfaces tied to this objective, as presently it was not clear.

The reviewer further noted relative to investigating long term thermo-mechanical properties of CF/polymer composites that there needs to be a more fleshed out description of the metrics and how FEA would complement the optimization effort. Additionally, the reviewer noted there are numerous options for sizing but asked if assessing other sizing and surface modifiers will be feasible before the project ends in October 2023. Finally, the reviewer commented on the sandwiching of 3D printed sensors, noting the research should be highly targeted given the project period and the goals and objectives should be more clearly stated.

Reviewer 3:

This reviewer suggested that the proposed future work seeks to get ahead of project delays but does not address reviewer concerns from previous or current years. The continuous CF process is high risk and a poor investment when this technology is already demonstrated by other groups at a higher TRL/MRL, according to the reviewer.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer believed that the project has a multi-functional benefit in terms of value to battery technologies, new materials and energy efficiency. The work is in its early stages and, as the TRL levels emerge, it will be clear which areas would be impacted the most. It is too early to say without scaling or a sense thereof.

Reviewer 2:

This reviewer affirmed that the project is relevant to VTO Materials subprogram objectives for vehicle lightweighting via better fiber adhesion to the matrix and through AM with embedded sensors but is not sure what automotive parts are realistically likely to be additively manufactured or whether the AM process can be used for the high-volume output needed within the automotive industry.

Reviewer 3:

The reviewer felt the technologies under development are unlikely to find broad application in the automotive area where they are targeted due to the cost and difficulty in scaling versus the minor benefits of embedded sensing.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer believed that the resources are sufficient to meet stated goals.

Reviewer 2:

Since the project ends this year, this reviewer believed that the funds are sufficient to reach the stated milestones in a timely fashion.

Reviewer 3:

This reviewer finds that the team of ORNL and UNT has adequate resources to conduct the project and they are utilizing it well.

Presentation Number: MAT203
Presentation Title: Low-Cost, High-Throughput Carbon Fiber with Large Diameter
Principal Investigator: Felix Paulauskas (Oak Ridge National Laboratory)

Presenter

Felix Paulauskas, Oak Ridge National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

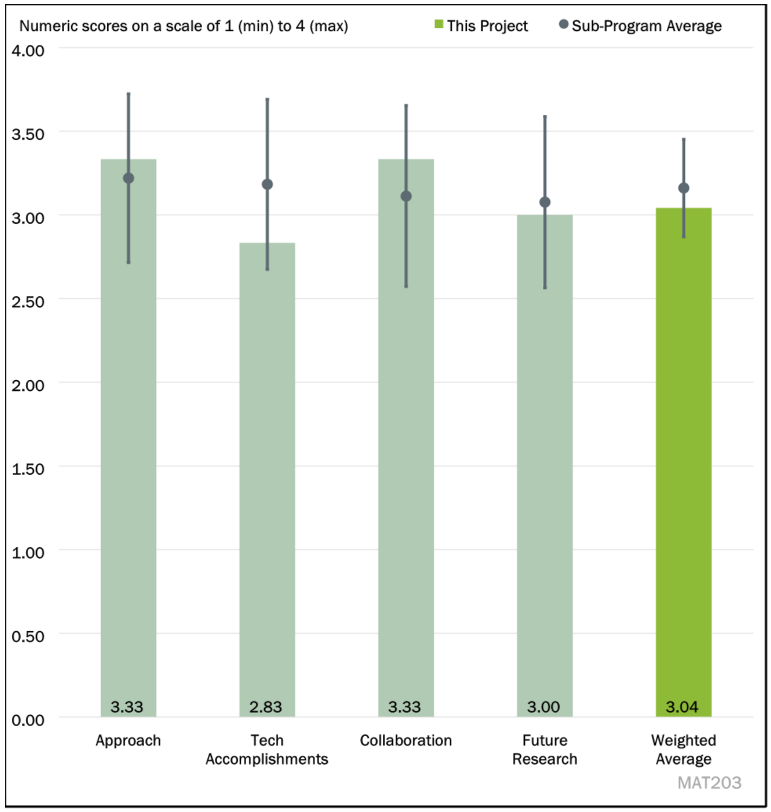

Figure 5-37 - Presentation Number: MAT203 Presentation Title: Low-Cost, High-Throughput Carbon Fiber with Large Diameter Principal Investigator: Felix Paulauskas (Oak Ridge National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer pointed out that the project aims to address the production costs of CF and feedstocks. The team has shown a reasonable timeline and some plans to accomplish the project goal in the reviewer's view.

Reviewer 2:

This reviewer observed that the barriers and technical targets being addressed in this project include the cost of CF feedstock and production and the availability of lower cost CF at a level necessary for large-scale impact for vehicle production. The approach for Fiscal Year 2023 included the demonstration and evaluation of a new CF produced at as close-to-pilot scale as practical. CF composite articles were made with a production-type process and testing was required to fully evaluate and define the advantages of the process. Cost models will be completed and utilized to evaluate the cost versus performance benefits in combining effects of textile PAN fibers produced via dry spinning and with larger precursor diameters. The design of the overall project started in the first year by establishing a baseline for this approach with CF converted from the dry spun textile precursor and demonstrating a fiber that was at least 25% larger in the "effective" diameter. The second year of the project produced CF that was at least 50% larger diameter than the project baseline established in the first year. The performance of the CF was demonstrated to be a minimum of 350 ksi in tensile strength, 33 Msi modulus, and 1% strain. The CF was further developed, and post treatment processes were scaled up at a project partner's facility. The cost target for the second year was to demonstrate that 25%-30% or greater savings are potentially achievable with this approach. The reviewer considers that the approach and project design supported the targets for the cost of CF feedstock and production and the availability of lower cost CF at a level necessary for large-scale impact for vehicle production. The project also addressed the VTO Materials technical goals for improved strength of composite materials used in vehicles. This was a three-year project, which is a reasonable timeline for this type of development.

Reviewer 3:

This reviewer reported that the project team focuses on dry spun acrylic fibers and plasma conversion that jointly reduce CF cost. Larger diameter fibers have advantages if the fibers can meet the target properties and cost. If successful, the dry spun acrylic fibers may replace the current expensive wet spun PAN precursor fibers and secure supply chains (upstream).

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

Since wet spun PAN precursor fibers are not currently made in the United States, this raises supply chain concerns. The project team seeks an alternative low-cost dry spun acrylic fiber with the goal to make acrylic fibers in the United States. The plasma conversion of large diameter acrylic fibers is encouraging (showing big cost savings). The CF properties and cost have met DOE targets and would be used to encourage making dry spun acrylic fibers in the United States to secure supply chains.

Reviewer 2:

The project made satisfactory progress in this reviewer's eyes. This is the final year for this project and the team could show more progress. The LCA and TEA would be critical to get an idea of the CF production cost.

Reviewer 3:

This reviewer related how the experiments with plasma oxidized and conventional carbonized 3.3dtex and 5.5dtex precursors (without steam stretching and with 50% steam stretching) produced fiber with very good mechanical properties that met the minimum goals of 250 ksi for tensile strength, 25 Msi modulus, and 1% strain and also met the target strength of more than 375 ksi with most specimens within 15% of 33 Msi target modulus. Conventional processing showed that the material was capable of meeting all minimum and probably all target goals with more optimization. There were limitations with the amount of available precursor, so the project had to be refocused on making larger quantities of CF from 3.3dtex materials that are being processed at one of the project partners, 4XT/4M, using advanced plasma oxidation, conventional carbonization and sizing, and advanced plasma surface treatment processes. The use of a manufacturing partner contributes to the success of transitioning the technology, if successful. The fiber produced at 4XT/4M will be processed into composite panels to be fabricated at a second project partner, the University of Tennessee, and compared with an industrial baseline material. This is considered a good approach for improvements over currently available CF materials. The project was delayed significantly because of COVID and associated business impacts, as well as equipment issues at 4XT/4M. This delayed conducting the cost/performance tradeoffs of leading diameter candidates. Also, the original supplier for the CF, Dralon, went out of business during COVID, so ORNL initiated collaboration with another offshore company, Sudamericana de Fibras (SDF), as a long-term candidate supplier of dry spun textile acrylic fiber. The technical accomplishments were significantly delayed because of these problems and the project is not targeting a U.S. supplier.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

This reviewer noted that the collaboration involved a national laboratory, ORNL, suppliers of CFs (Dralon, 4XT/4M, and SDF), and academia (University of Tennessee). For this size project ($500,000 per year), the collaborations support a successful development of CF with large diameters.

Reviewer 2:

This reviewer believed that the collaboration between ORNL, 4XT and the University of Tennessee has been great. The scale-up processing has been demonstrated in ORNL and 4XT. It is expected that integration of plasma oxidation and carbonization will further lower conversion cost.

Reviewer 3:

The team has good collaboration with 4XT/4M, according to this reviewer, who, nonetheless, believes that it would be great to have more collaboration with raw materials supply chain industries.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer said that the team has some future research plans. The future plans make sense and the targets are achievable.

Reviewer 2:

This reviewer noted that, although the project will complete at the end of Fiscal Year 2023, future research was proposed. This included pursuing the utilization of a combination of lower cost dry spun fibers and advanced conversion technologies, assessing a broader range of diameter versus economics and CF production/performance tradeoffs than previously explored, and evaluating projected resin infusion advantages and possibly improved interfacial properties.

Reviewer 3:

The proposed future research identified by this reviewer includes assessing overall technical and economic advantages. This will help establish a strategy plan for United States. CF supply chains (upstream). It is expected that low-cost dry-spun acrylic fibers can be made in the United States. Testing milestones depend upon fiber availability.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer affirmed that the project supports the VTO Materials subprogram objectives.

Reviewer 2:

This project is believed by this reviewer to be relevant to supporting the VTO Materials subprogram objectives to develop lightweight materials such as composite materials for vehicle parts and to reduce the cost of CF feedstock and production that will improve the availability of lower cost CF fiber at a level necessary for large-scale impact for vehicle production.

Reviewer 3:

CFs are critical, according to this reviewer, to reducing vehicle weight/energy consumption/carbon emissions, and lowering cost for lighter and smarter EVs. The project directly supports the VTO Materials subprogram objectives and secures supply chains.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer found that, the resources are sufficient.

Reviewer 2:

This reviewer commented that this was a three-year project with $500,000 per year in funding for one national laboratory and a university. The industry partner provided services in kind to be able to produce the end product. This is considered by the reviewer to be sufficient resources for this type of project.

Reviewer 3:

This reviewer noted that the project leverages the resources of ORNL, 4XT and University of Tennessee, and is sufficient for the project to achieve the milestones in a timely fashion.

Presentation Number: MAT204
Presentation Title: New Frontier in Polymer Matrix Composites via Tailored Vitrimer Chemistry
Principal Investigator: Tomonori Saito (Oak Ridge National Laboratory)

Presenter

Tomonori Saito, Oak Ridge National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

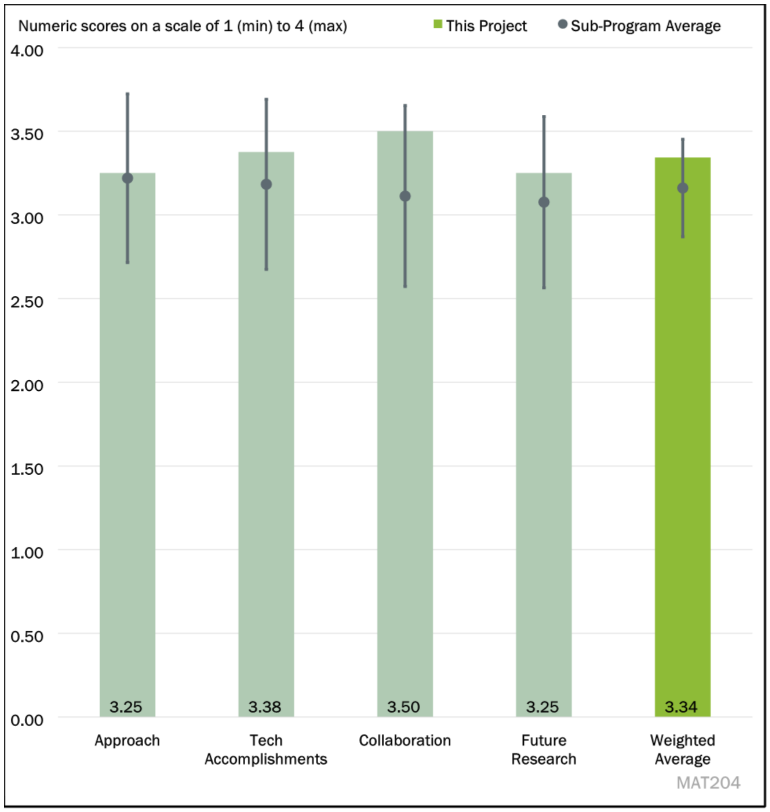

Figure 5-38 - Presentation Number: MAT204 Presentation Title: New Frontier in Polymer Matrix Composites via Tailored Vitrimer Chemistry Principal Investigator: Tomonori Saito (Oak Ridge National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer pointed out that this project deals with the following objectives: develop cost-effective new vitrimer resins for CF composites; develop the manufacturing process of CFRPs and improve the fiber-matrix interfacial adhesion; validate the manufacturing of fast-processable, recyclable and repairable vitrimer resins and CFRPs while maintaining their superior mechanical properties. The team has presented excellent progress in advancing these objectives, according to the reviewer. The resins being developed are very well aligned with DOE objectives of circularity and energy savings. The project has demonstrated achieving high tensile strength and processability for CFs. It has also shown a valuable process capable of thermostamping preforms with CF vitrimers, which is of high value to automotive and related applications. This also advances the work to high TRL levels. The process also demonstrates adding a dynamic covalent bond to commodity polymers, increasing their strength and durability. Interfacial adhesion with a fiber-matrix was demonstrated, which helps translate properties. All these successes point to advancing the objectives by the team.

Reviewer 2:

This reviewer commented that the work shows excellent results for initial property evaluation, including property retention during recycling but the reviewer complains of having yet to see in this or in any other presentation, long-term environmental durability and creep performance results. These test data will determine a use case for these novel materials.

Reviewer 3:

This reviewer shared that a tris-diol vitrimer was developed as a novel polymer matrix. The vitrimer exhibits decent mechanical properties at a high processing temperature. An iridium-based catalyst is needed for polymer functionalization (i.e., installing borate), which raises the cost. The reviewer is unclear on the ease/cost effectiveness of the synthesis and purification of tris-diol.

Reviewer 4:

This reviewer found that the project itself is well designed and interesting, because it investigates many vitrimer systems that might be of relevance to CFRCs. Excitingly, the work demonstrates the potential behind two different vitrimer systems: disulfides and boronic esters. A large weakness is that an analysis is not performed until the end of the project, so the reviewer found it hard to assess the viability of these specific chemical approaches. Boronic esters may be cost prohibitive for vehicle applications; the specialty monomers used in the disulfide approach may also prove to be cost prohibitive. TEA/LCA early in the project, instead of at the project milestone, could better drive resin development. Without analysis, specific alignment with VTO goals is hard to track. The reviewer also found it hard to understand why two different systems were explored. Benefits between the different approaches should be highlighted.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer refered back to comments provided in the previous question. The technical accomplishments are on target. The central premise of vitrimer recycling is being addressed at the basic science level without losing sight of higher TRL scale up. This is, indeed, commendable to the reviewer, who states that all the comments made above apply here.

Reviewer 2:

As the reviewer previously stated, the test results thus far are very encouraging, but much work has yet to be completed to support use of this technology as an engineering material system.

Reviewer 3:

The team has shown the re-processibility of the new vitrimer and its CFRCs to the satisfaction of the reviewer. Degradation of the CFRCs was also demonstrated, although the research has been focused on recovery of the CFs. Recovery of the monomers is also highly desired, which could very likely be achieved, but still needs to be demonstrated. Also, the CFRCs exhibit strains of over 10% or even 20%, which seem to the reviewer to be much higher than CFs can commonly reach.

Reviewer 4:

This reviewer described how the project team has shown the ability to make multiple resin formulations for re-use over multiple material lives and has shown similar performance across multiple material lives. The sizing of the fibers to participate with the dynamic chemistry is well done and shows enhanced properties. This will surely further help the development of recyclable composites. Overall, the project seems focused more on resin development then on composite development. This became evident in some of the answers to reviewer questions around composite performance. The reviewer suggests that the project team should examine the creep of their composite at service temperatures more in depth, as well as provide better explanations for the enhanced properties. Notably, the enhanced elongations at break of the composites is exceedingly high. This is an exciting result but defies the conventional wisdom around composite performance. Mode of failure should be further documented to understand this. The project team should explicitly state how their chemistry enables advanced performance, according to the reviewer.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

This reviewer reported that the project team has coordination with material suppliers.

Reviewer 2:

This reviewer approved that the team is fairly well coordinated. ORNL is teamed with the University of Tennessee and resin suppliers Hexcel, Krayton and Hexion. This is a logical team collaboration. It is surprising to the reviewer that the team does not have a tier one manufacturer or OEM on the team. With this excellent progress, which would be a natural outcome of the work.

Reviewer 3:

This reviewer found it very good to see collaboration with Hexcel, Huntsman, Hexion, who are leading suppliers that have knowledge and resources to commercialize the technology. Material cost, however, was not discussed and is an important factor for the reviewer.

Reviewer 4:

This reviewer commended that the team members have complementary expertise and contribute in different ways. As was mentioned in the presentation, if one more collaborator from automobile industry is on board, that would make the team even stronger.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The proposed future research tasks are clear enough for this reviewer, including repairability/recyclability study, obtaining cost-effective vitrimer-based CFRCs, and conducting a TEA. Given the current progress of this project, the team should be able to accomplish those tasks within the project timeline.

Reviewer 2:

This reviewer identified the team-proposed future work was to: (1) Further demonstrate repairability and recyclability but it was not clear to the reviewer how the team plans to do this, or how it differentiates from what has already been accomplished. Some quantification would help. (2) Prepare cost-effective vitrimer-based CFRPs and achieve a 700 MPa composite tensile strength. The target is good to have but raises the questions of how and what basis the target is to be achieved. (3) Conduct TEA and investigate the circular economy; some level of specificity is needed to qualify these generic terms.

Reviewer 3:

As previously noted, the reviewer believes that TEA and LCA should have been done earlier in the project, but its addition will greatly enhance this work. Demonstrating repairability is also a strong milestone.

Reviewer 4:

The future work looked fine to this reviewer, but data are needed on environmental durability, particularly creep near expected service temperature that would be just below the glass transition temperature (Tg).

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

For this reviewer, the project has relevance to multiple areas since circular economy is key to almost all the listed areas. The work is primarily in materials development.

Reviewer 2:

This reviewer confirmed that the project is very good for VTO Materials subprogram objectives in composites sustainability, and perhaps novel processing for cost reduction.

Reviewer 3:

According to this reviewer, given their light weight, high mechanical performance, and recyclability, the proposed vitrimers and CFRCs can be utilized in automobile manufacturing in future as sustainable materials and to enhance fuel economy.

Reviewer 4:

This reviewer restated that the approach of designing vitrimers is well conceived and aligns with VTO goals around recycling and reuse. Additionally, their recyclability is well documented. However, it is hard to understand alignment to project goals without analysis. Analysis should be conducted earlier in the project, or in future projects, to demonstrate and guide the approach. Currently, too many questions arise for the reviewer around cost of resin, cost of reprocessing, environmental impact, and manufacturing process to comment completely on alignment.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The funds appear to this reviewer to be sufficient; however, more effort should be dedicated to early TEA/LCA on future projects.

Reviewer 2:

This reviewer found that the team has adequate resources across the board in terms of processing, thermo-mechanical, thermal and related characterization, polymer formulations, composites preparation, etc. No additional resources would be needed in the reviewer's opinion.

Reviewer 3:

This reviewer applauded the team as being very strong to move the technology forward.

Reviewer 4:

This reviewer considered that the team has sufficient resources to complete this project in a timely fashion.

Presentation Number: MAT205
Presentation Title: Adopting Heavy-Tow Carbon Fiber for Repairable, Stamp-Formed Composites
Principal Investigator: Amit Naskar (Oak Ridge National Laboratory)

Presenter

Amit Naskar, Oak Ridge National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 67% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 33% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

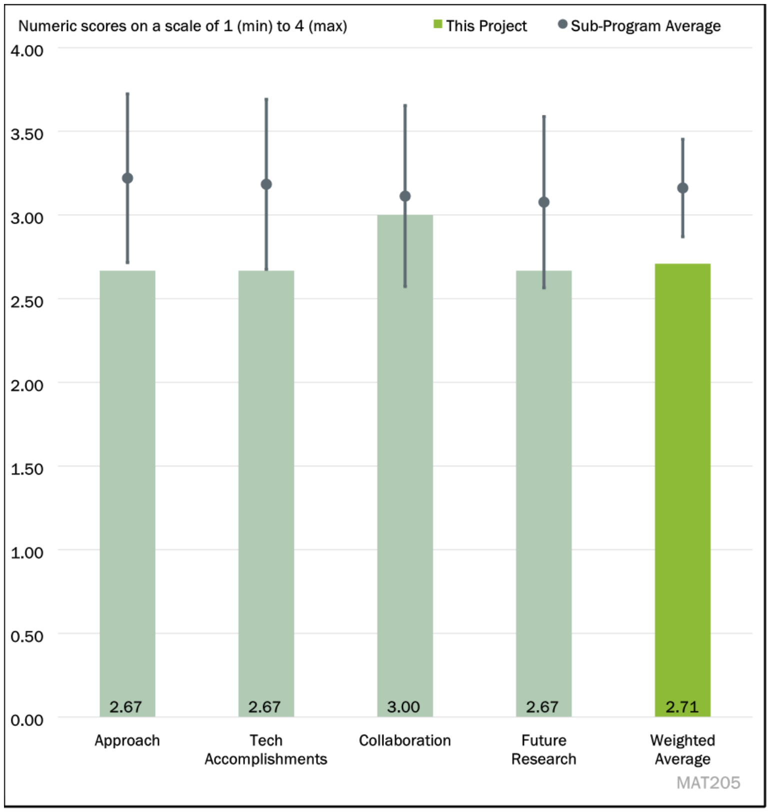

Figure 5-39 - Presentation Number: MAT205 Presentation Title: Adopting Heavy-Tow Carbon Fiber for Repairable, Stamp-Formed Composites Principal Investigator: Amit Naskar (Oak Ridge National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

One of the objectives appears to the reviewer to be the development of sizings for PP matrix materials; however, the reviewer did not see any work being performed on interfacial compatibility. The approach does not seem very ambitious.

Reviewer 2:

This reviewer summarized the project’s stated objectives: (1) develop and commercialize high throughput manufacturing technologies with new interfacial engineering methods for efficient reinforcement of thermoplastic matrices using CFs; (2) translate the method for large tow CFs; (3) deliver repairable low-cost thermoplastic composites with multi-layered stamp formed structures with outstanding mechanical performance (0.8 1.4 GPa tensile strength, 50 100 GPa Young’s modulus, and approximately 10% failure strain); and (4) develop processing technologies that enable 30%–50% cost reduction in composite parts. The reviewer found these objectives were generally good. The team’s approach brings in thermoplastic resin films along with wide tow to produce what they call commingled stampable forms. The term commingled is somewhat loosely used here, in the reviewer’s opinion, since the traditional commingled form has fiber reinforcement and resin also in the form of filaments (like fibers). The team has shown several basic level studies with the low-cost CF and some aspects of commingling. The work is generally in the right direction but still far away from the stated objectives. The team is developing an understanding of the thermal and process science of these materials. There is some effort to use the tow along with the resin to produce a sheet form. The reviewer observed that the slides were not numbered, making it more difficult to reference.

Reviewer 3:

This reviewer deduced that the project is only 50% complete ahead of the September 2023 end date which leaves only three months to complete the other 50%.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The presentation of continuous and chopped CF makes it difficult for this reviewer to sort out what data are being reported. For instance, it appears as if interlaminar shear strength is being reported for a chopped fiber composite where there would be no interlaminar region and, thus, the test results would not make sense. The reviewer was unclear about why the higher loading of CF leads to reduced strength with slower cooling.

Reviewer 2:

This reviewer found that the technical results are generally laid out logically. However, the key issue that the reviewer has with this brief presentation is the lack of a rationale/logic for why each study is being conducted. Also, the graphs/data are poorly labelled/annotated making is very difficult to understand what they are intended to say. As an example, for Slides 7-11 (assuming these numbers, since the slides are not numbered) characterization data are presented with conditions of freezing, quenching, etc. However, there is no accompanying information on what these are, why they are important in the context of the work, and what should the reader draw from them. All the reviewer understood was that the team has good characterization equipment and used it. The graphs are extremely hard to read and could use some professional editing. The stress-strain curves on Slide 12 are not even identified. They show five curves, but without identification. Also, the approach uses chopped fibers that were wet laid, but Slide 12 shows continuous wide tow. The reviewer is not clear on what intermediate form is being considered/characterized. If the plan is to use chopped fibers, then the data should be commensurate to that. The same lack of explanation/annotation could be said of Slide 13 and Slide 14. Overall, the technical work seems to take PP resin, along with the wide tow to produce wet laid mats and test them. It also seems that the wide tow is converted to chopped fibers and then used in the wet laid process. Hence, the true value of the wide tow may not be fully realized. The reviewer believes that the work is not yet fully aligned with the rather aggressive objectives.

Reviewer 3:

The ability of this project to achieve high throughput is not clear.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

This reviewer said that the collaboration seems to be appropriate.

Reviewer 2:

This reviewer pointed out that the team comprises ORNL, University of Tennessee Bredesen Center, and Endeavor Composites. The collaboration is logical and seems to the reviewer to be functioning well. The team can carefully review their objectives and align the work better.

Reviewer 3:

This reviewer indicated that increased collaboration with an automotive OEM would be beneficial.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer found the proposed tasks to be reasonable though there seems to the reviewer to be quite a bit of work left to complete the project.

Reviewer 2:

This reviewer found very little detail was provided on the future research, which includes ambitious/unrealistic scale up plans.

Reviewer 3:

This reviewer offered the following comments: (1) Regarding ongoing work with Endeavor Composites likely being adopted for scaled up manufacturing, the reviewer commented: This is somewhat vague without knowing which form, volume fraction, and interface conditions would be pursued toward scale up. The reviewer is unclear about what “scale up” means in this context – size, asset base, commercialization (this word has been used in the first objective) – but the work does not point to any of that yet. (2) Regarding TEA and LCA of the products needing to be demonstrated, the reviewer commented: This is not entirely trivial and the reviewer wondered how this is possible for a project ending September 2023. (3) Regarding required development of high TRL R&D plan, the reviewer commented: This is a very vague statement and does not provide the reviewer anything to base what “high TRL R&D plan” means. (4) Regarding quantifying activation energies for forming chemisorbed matrices and identifying stabilized structures of polymer matrix attached to the CF surface, the reviewer found to be satisfactory. (5) Regarding conducting experiments at different temperatures to measure bound polymer fraction, the reviewer found this to be satisfactory. (6) Regarding demonstration of the CFRP stamping process for multi-layered structures, the reviewer commented: This needs some definition of how this would done, including a tool(s) plan, asset considerations, and process parameters to be developed. (7) Regarding the use of high throughput, low-cost large-tow CFs for stamped CFRPs, while making use of the developed interfacial chemistries that result in enhanced mechanical performance and crashworthiness, the reviewer questioned in what form his would be done and referred back to prior comment on the Slide 12 information. (8) Regarding remolding/restamping of structures, the reviewer was not sure what this means. (9) Regarding demonstrating the concept in small scale, the reviewer was not clear which concept, but accepted the comment. (10) Regarding building a cost model based on the current data and potential advantage of recyclability, the reviewer found this to be satisfactory but again not trivial. Overall, the reviewer found the work plan is good in terms of a layout, but shared that, based on years of experience, the reviewer would respectfully offer that completing all these efforts before September 2023 would require Herculean efforts.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer stated that composite materials are important to VTO.

Reviewer 2:

This reviewer believed that the work relates to materials, batteries, and energy efficiency.

Reviewer 3:

This reviewer commented that the effort is relevant assuming throughput and cost effectiveness are achieved.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer found that the overall team complements in terms of resources and other resources are adequate.

Reviewer 2:

This reviewer accepted that the resources are appropriate.

Reviewer 3:

It appears to this reviewer that little work has been accomplished with the budgeted funds.

Presentation Number: MAT206
Presentation Title: Soft Smart Tools Using Additive Manufacturing
Principal Investigator: Jay Gaillard (Savannah River National Laboratory)

Presenter

Jay Gaillard, Savannah River National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

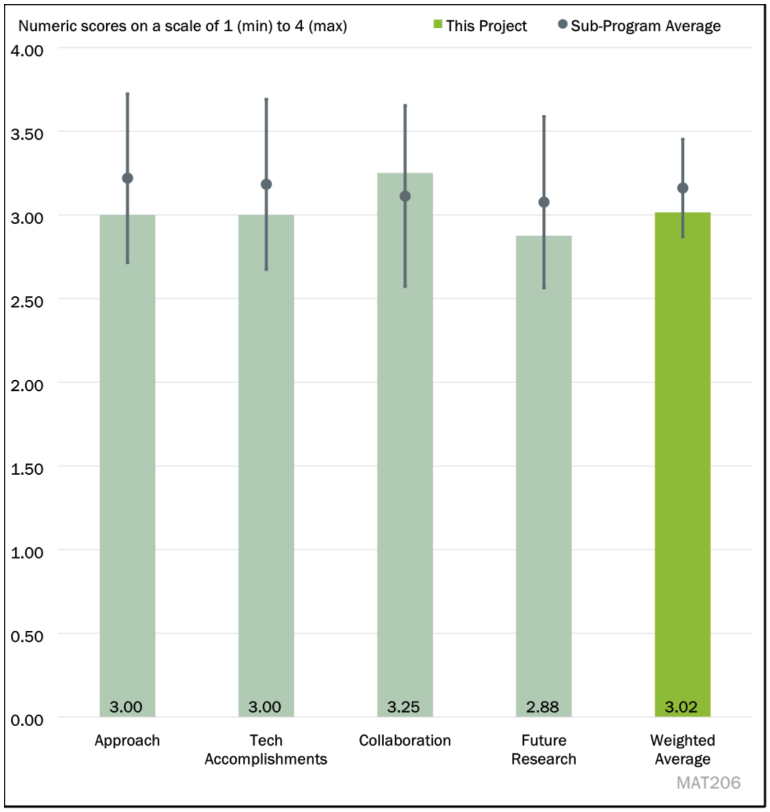

Figure 5-40 - Presentation Number: MAT206 Presentation Title: Soft Smart Tools Using Additive Manufacturing Principal Investigator: Jay Gaillard (Savannah River National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer commented that the project is well designed and well planned with a focus on the development of soft, smart composite tooling by AM. The technical barriers addressed are the extensive time spent engineering filament coating scale up and optimizing annealing parameters with carbon nanotubes (CNTs).

Reviewer 2:

This reviewer described how the objective of this project is to enhance the durability, life expectancy, strength, and conductivity of composite tooling using 3D printing, as demonstrated in the team’s initial AMR slides from 2021. The team opted for CNTs as an electromagnetic susceptor for microwave heating, due to their superior heating performance compared to other alternatives. In year 2021, higher strength and modulus of 3D-printed samples with CNTs through microwave annealing has been observed as compared to non-annealed samples. In 2022, the team made CNT-coated continuous carbon fiber (CCF) prepreg tow and showed the increase in the heating performance. Building upon these accomplishments over the past 2 years, in Fiscal Year 2023, the team planned to scale up the manufacturing of CNT-coated CCF tow and intends to integrate sensor technology into the tooling. The overall direction and the design of the project appear adequate, and the proposed timeline is reasonable to the reviewer.

Reviewer 3:

This reviewer noted that the project team identified potential technical barriers for this project and the project aims to develop soft, smart composite tooling by additive manufacturing.

Reviewer 4:

This reviewer referred to polyaryletherketone (PAEK) concerns identified elsewhere in this review.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer found that the project team made significant progress relative to the project plan. The LCA and TEA data indicate significant improvement and cost reductions. CNT-coated CF samples showed very good properties after microwave annealing.

Reviewer 2:

This reviewer recorded that the team suggests overcoming the identified barriers of the manufacturing cost since the automotive tooling for making vehicle components by computer numerical control is energy and emission intensive. The team suggests that tooling production via 3D printing could lead to savings of about 50% in mold lead time, 40% in primary energy and GHG emissions as well as a 30% cost savings, assuming a 1-million-cycle lifetime. The team used CNT-coated CCF and introduced electromagnetic annealing to internally heat the composite. The team improved the mechanical/thermal properties of CCF at significantly lower energy. One question the reviewer poses is about the comparison data showing that the improvement is found only after the maximum force is applied, so the effectiveness in practical application is not clear (see figure on Slide 7). The team found that the CCF-reinforced 3D-printed thermoplastics have exhibited higher tensile properties and fiber volume fractions of up to 64%. However, the data are not presented well and the referenced papers [1-6] are not the about the team's work.

Reviewer 3:

This reviewer lauded that the team has shown great technical progress in a concerted manner. The reviewer is, however, concerned that the move to the PAEK thermoplastic will present more technical challenges than anticipated, suggesting that additional effort should have been spent on this earlier in the project.

Reviewer 4:

This reviewer noted that the team showcased several research outcomes this year. In terms of scaling up the manufacturing of CNT-coated CCF tow, improvement was achieved by increasing the production amount from a 300-ft long filament to a 3000-ft long filament, representing a 10x increase. Additionally, the team presented its findings from life cycle energy assessment and a TEA, demonstrating that the new technology being developed will lead to reduced energy consumption and lower manufacturing costs. Regarding the development of embedded sensors, the team presented its progress in two areas. Ink formulations were developed for direct ink writing and a technique was developed for printing a thermocouple on CCF. However, both ink development and thermocouple printing were already presented in a previous AMR meeting. The team claimed an increased performance by 20% in shear strength through microwave annealing. However, upon reviewing Slide 7, the force-displacement graph does not exhibit any noticeable increase in the maximum force to this reviewer. The team initially proposed sensor development for strain sensors and curing sensors as well as thermocouple sensors. However, the reviewer finds that this presentation lacks information about the strain sensors and curing sensors.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

This reviewer believed that the project team has good collaboration with Clemson University and Mainland Solutions.

Reviewer 2:

This reviewer noted that the team is led by Savannah River National Laboratory in partnering with Clemson International Center for Automotive Research, and Mainland Solutions, LLC. The team has individual roles: Savannah River National Laboratory is working on electromechanical susceptor design and continuous fiber and sensor 3D printing; Clemson University is working on mechanical testing; Mainland Solutions is working on the production of the CNT-coated 3D printing filaments and production of materials needed for the embedded sensors.

Reviewer 3:

The reviewer commented that an additional national laboratory partner would have further improved this score.

Reviewer 4:

This reviewer noted that the team is comprised of members from Clemson University and Mainland Solution, a material manufacturer. The inclusion of an OEM or a tier 1 company from the automotive industry would be immensely beneficial to the team because it would assist them in identifying the ideal target application.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer pointed out that this is the last year of this project.

Reviewer 2:

This reviewer believed that the mechanical performance characterization is a part of this project and a way to prove the success of the project, but it is not complete enough to put into future work.

Reviewer 3:

This reviewer commended that the future work has a precise proposed scope. Large challenges, however, are foreseen by the reviewer in pivoting from nylon to PAEK, which the team did not fully address in the scope.

Reviewer 4:

The reviewer observed that the team proposed the following tasks: (1) investigating the use of PAEK as an alternative material for better durability and improved durability and quantifying its effects; (2) developing a multi-head printing technique for sensor integration; and (3) demonstrating market viability. Given that the project is scheduled to conclude in just a few months, accomplishing both Task#1 and Task#2 appears to be demanding in the reviewer’s view.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer believed that the project nicely addressed the materials and manufacturing areas of the VTO missions.

Reviewer 2:

This reviewer affirmed that the scope of work is well aligned with the overall VTO Materials subprogram objectives.

Reviewer 3:

This reviewer offered that tooling is a large, sometimes hidden, cost of conventional manufacturing and this is an innovative approach to reducing tooling costs using AM, which the reviewer finds very commendable.

Reviewer 4:

The project, according to this reviewer, is highly relevant to VTO Materials subprogram objectives. Due to its high cost and long lead time, the development of tooling technology greatly affects the automotive industry. Upon successful completion, the proposed project will result not only in the reduced costs and short lead time, but also in parts with improved quality based on integrated sensor data.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer said that the team has sufficient resources to finish the project's milestone.

Reviewer 2:

This reviewer determined that the team has sufficient resources to complete the planned tasks.

Reviewer 3:

The resources appear to this reviewer to be reasonable and sufficient for successful completion.

Reviewer 4:

This reviewer found the resources available to be sufficient to meet stated goals; however, the PAEK challenge may require a resource loading shift.

Presentation Number: MAT207
Presentation Title: Multi-Material, Functional Composites with Hierarchical Structures
Principal Investigator: Christopher Bowland (Oak Ridge National Laboratory)

Presenter

Christopher Bowland, Oak Ridge National Laboratory

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

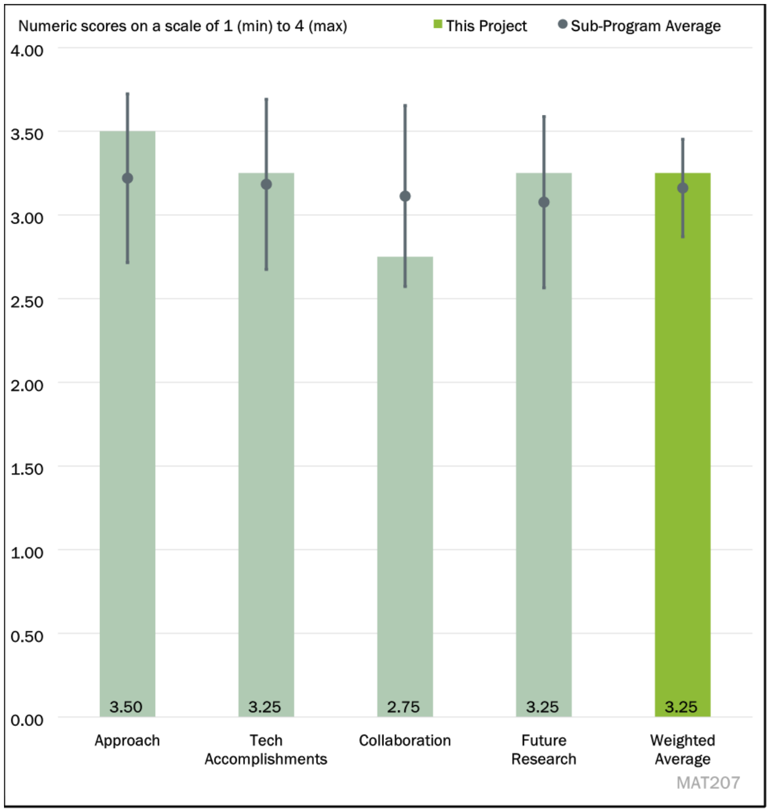

Figure 5-41 - Presentation Number: MAT207 Presentation Title: Multi-Material, Functional Composites with Hierarchical Structures Principal Investigator: Christopher Bowland (Oak Ridge National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer said that the project has clearly addressed the barriers and technical targets proposed for the project. The technical target to optimize the crash energy is very relevant, and the reviewer feels that it would be nice to have a few experiments demonstrating this capability with the developed material.

Reviewer 2:

The complex technical barriers were addressed well for this reviewer and demonstrated with project progress and all milestones completed at the time of the AMR. The project continued to take a methodical approach to the integration of *in situ* damage monitoring and enhanced mechanical properties in CF/ABS mixes and CF composite laminates. The reviewer considers this to be great progress.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer believed that there was significant accomplishment in achieving 60%–100% improvement in in-plane shear strength and energy release up to 250°C. All progress was commensurate with the plan as developed and technical challenges were met with success. Delay in fatigue testing and *in situ* measurements have put these tasks behind schedule, but they are underway with the collaborator.

Reviewer 2:

This reviewer considered that good progress has been achieved in validating the electromagnetic characterization with various amounts of $BaTiO_3$. This accomplishment appears to have been completed last year. However, the reviewer would find it useful to determine a threshold voltage that causes specific failure of the composite using this technology. A significant achievement is that the team has successfully developed a process to deposit PAN nano fibers on the CF. Additionally, determining the appropriate thermal treatment to maximize strength is excellent. The tensile results of the samples were tested for a layup of 45/-45 (Slide 12). However, this layup only provides the shear stiffness of the composite. The reviewer desired to see the tensile test results for those samples, which could provide a greater understanding of the various interfaces. On Slide 13, a significant improvement of 137% was found in transverse tensile strength with PAN nano fiber orientation. This improvement may be attributed to the use of a low-strength matrix material (2 MPa). The reviewer is unaware of whether this matrix material will be reasonable to use in practical applications.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer noted that the project involves Columbia University as a collaborator in evaluating the fatigue testing. The reviewer is unsure of the efforts by the other collaborating partner, Enfluxx Tech, LLC.

Reviewer 2:

To this reviewer, the collaboration appeared to be the weakest part of the project because of delays in providing funding to the collaborator to begin fatigue testing. The work has begun, but the project is nearly over. A successful license agreement was completed for the technology.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer observed that the remaining challenges for the project are well-documented. However, higher priority should be given to scale-up demonstrations, according to the reviewer, who also suggests that cost modeling is another critical step that has the potential to uncover new research areas for reducing the overall cost.

Reviewer 2:

This reviewer believed that the project team has developed an effective series of technical and TEA tasks to complete, but there is no discussion of future implementation of the technology into vehicles and what parts the materials could best be used to reduce weight.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer found that the project is highly relevant to the automotive industry as it focuses on developing new multi-functional composite materials that can consolidate multiple components. The developed materials are lightweight compared to existing materials, thus improving the efficiency for the transportation industry.

Reviewer 2:

This reviewer described how the project is integrating sensor technology and enhancing composite strength that will allow for improved reliability and lower weight composites by reducing excessive design. This reduction is because of increased confidence levels and will further reduce the cost along with the weight reduction if the TEA analysis can show a minimal cost addition.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer was satisfied that the project has sufficient resources to execute the remaining tasks.

Reviewer 2:

This reviewer accepted that the resources are sufficient, as evident by the progress and accomplishments of the milestones which are on target.

Presentation Number: MAT208
Presentation Title: Efficient Synthesis of Kevlar and Other Fibers from Polyethylene Terephthalate (PET) Waste
Principal Investigator: Daniel Merkel (Pacific Northwest National Laboratory)

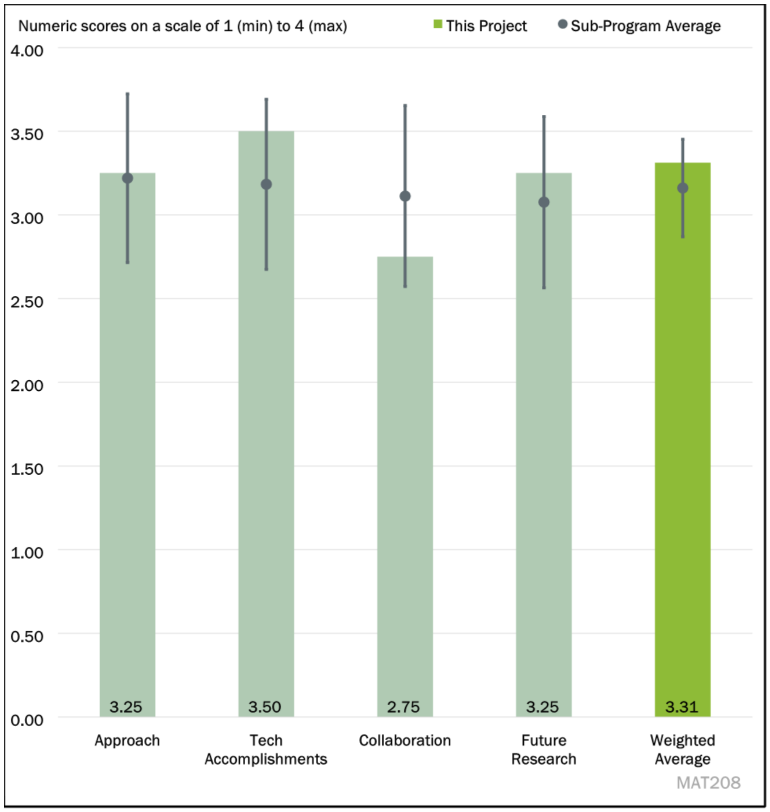

Figure 5-42 - Presentation Number: MAT208 Presentation Title: Efficient Synthesis of Kevlar and Other Fibers from Polyethylene Terephthalate (PET) Waste Principal Investigator: Daniel Merkel (Pacific Northwest National Laboratory)

Presenter

Daniel Merkel, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer noted that the project aims to fabricate Kevlar fibers from polyethylene terephthalate (PET) waste. While the initial approach was good, the project ended up recovering terephthalic acid from PET and conducting the same chemistry and fiber spinning process as the current manufacturing of Kevlar. The reviewer agrees that it is worthwhile to gain the capability to de-polymerize PET, synthesize polyamide, and spin fiber to Kevlar. However, the concept of the current research will not have a significant impact. PET waste-based terephthalic acid may already be available from PET producers, rendering the depolymerization process of limited value. Thus, unless the project can have more added advantages, the strategy may not provide a significant practical advance to the industry.

Reviewer 2:

This reviewer believed that the team has a good approach to using a mixed PET waste stream to synthesize aramid fibers as a route to potentially lower their cost. Good characterization work has been performed on the synthesized material prior to fiber spinning, and it seems that the team has figured out the proper material synthesis approach to perform the spinning tasks. And the team showed good fiber spinning results.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer recounted how the initial approach of PET depolymerization did not provide satisfactory molecular weight and the team had to pivot the approach. Considering that setback and needing to figure out fiber spinning conditions, etc., the team made reasonable progress.

Reviewer 2:

This reviewer found great progress in overcoming some of the fiber spinning challenges that existed at the time of last year's AMR presentation. The team put together good quantifiable milestone targets to assess the success of the project. All milestones seem to have been successfully met and the project looks to be on schedule. Poly-paraphenylene terephthalamide has many challenges to characterize due to the solvents required to dissolve this material. Encouragingly, the team found a good alternative to performing traditional molecular weight characterization.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1: .

This reviewer believed that a good collaboration with Washington State University was established. Another collaboration may be needed to perform single fiber testing at different strain rates. If this research continues, single fiber tensile testing would be desirable.

Reviewer 2:

While Washington State University is listed as a partner, their role is not clear to this reviewer. There is no clear indication of active collaboration.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The future research plan was reasonable to this reviewer. Performing TEA/LCA is good; however, the team needs to carefully think through what technological novelty this project provides. Unless PET can be depolymerized much more effectively than the current state of the art or a completely new process to produce Kevlar can be developed, this project has minimal novelty.

Reviewer 2:

The proposed future work was clearly defined for this reviewer, but some tasks may be very ambitious to perform by the end of the project. The fiber spinning optimization requires a lot of effort. Composite fabrication may be an ambitious target since so much material will be needed to fabricate a bulk-scale composite. The new spinning setup will definitely help with producing enough fiber for a composite, but it will still require significant spinning effort to produce enough highly consistent fibers. And, typically, aramid fibers are produced as woven fabrics, which is hard to perform at a laboratory scale. Composite fabrication is an appropriate goal to end the project. The results from the TEA at the end of the project to evaluate how this waste PET approach compares to existing aramid fiber costs could be interesting.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer believes that the project is relevant, but the team needs to revise the strategy.

Reviewer 2:

According to this reviewer, the project is very relevant to the VTO Materials subprogram objectives by producing cheaper fibers for vehicle lightweighting using an approach that can utilize waste materials.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer commented that the team acquired various equipment and has had sufficient funding to conduct the research.

Reviewer 2:

This reviewer considers the resources sufficient to achieve the stated milestones in a timely fashion to end this project this year.

Presentation Number: MAT209
Presentation Title: Bio-based, Inherently Recyclable Epoxy Resins to Enable Facile Carbon-Fiber Reinforced Composites Recycling
Principal Investigator: Nicholas Rorrer (National Renewable Energy Laboratory)

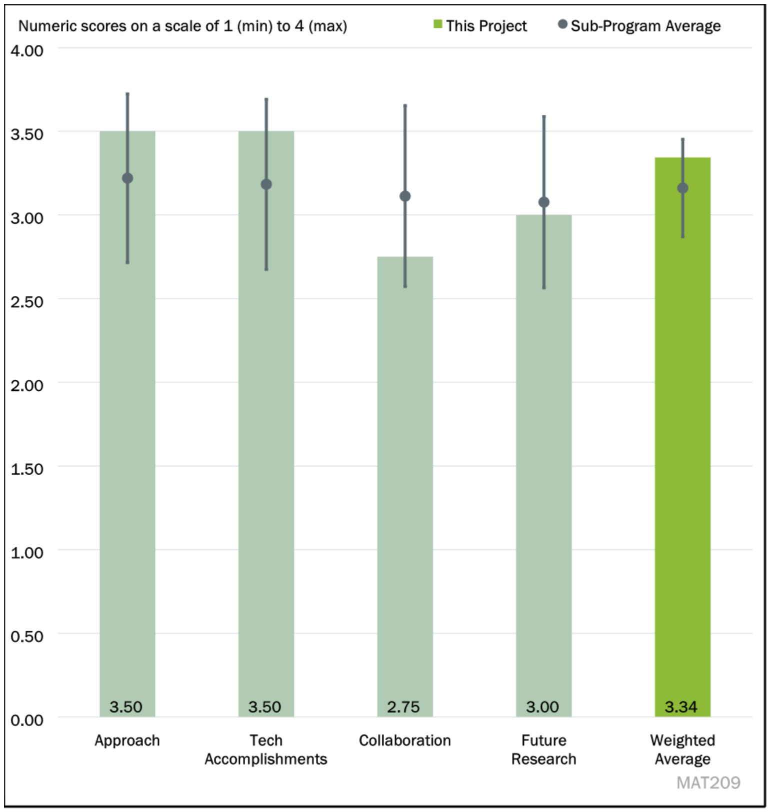

Figure 5-43 - Presentation Number: MAT209 Presentation Title: Bio-based, Inherently Recyclable Epoxy Resins to Enable Facile Carbon-Fiber Reinforced Composites Recycling Principal Investigator: Nicholas Rorrer (National Renewable Energy Laboratory)

Presenter

Nicholas Rorrer, National Renewable Energy Laboratory

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The project provides an approach that is interesting to this reviewer for the development of bio-derived composites that provide the additional benefits of being designed for chemical recycling. Beyond recovery of the polymer constituent, this approach also lends itself to recovery of the reinforcing fiber, which could represent significant added value, depending on the type of fiber used.

Reviewer 2:

This reviewer found the approach to create covalently adaptable networks and CFRPs from bio-based building blocks is good, especially for achieving low GHGs. Also, the LCA clearly shows recycling CF will significantly reduce GHG and energy input. The overall approach is good, although the team will probably need to readjust various aspects of the technology to make it commercially viable. For example, while the presenter mentioned that the target mechanical performance was to achieve equivalence to that of epoxy based CFRPs, it was not perfectly clear to the reviewer what exact target performance (values) this project is pursuing. Depending on the specific use and specific vehicle parts, the required mechanical properties will differ. Additionally, requirements for long term stability and hydrolytic stability are unclear. Once the team can evaluate various aspects and properties, this concept can go to a much higher TRL, according to the reviewer.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer observed that the data reported demonstrate significant progress towards the overall project objectives. Production of sample composite panels for testing was demonstrated in addition to recovery of the fiber preforms. These were used in subsequent trials to demonstrate repeated recycling loops and maintenance of mechanical properties. One potential drawback is the emphasis on resin infusion, which may not be well suited to a broad array of geometries encountered in automotive applications. However, this limitation may not exist in other industry sectors.

Reviewer 2:

This reviewer found that the team accomplished creation of thermoformed parts along with a detailed LCA/TEA. Overall progress and technical accomplishment are good. Especially, LCA results will be very helpful to be shared in the community to understand the impact of CF resins, as well as their recycling. There are potential concerns to this reviewer on the thermo-mechanical properties, which the team should consider addressing. The data showed Tg around 70^{o}C–80^o C, which is on the low side. While such low Tg helps processability, it raises concerns that the thermal stability could be too low for the resins to be used for some vehicle parts. From the dynamic mechanical analysis curve, the CFRP could start softening at 60^{o}C or so (depending on frequency). The team should consider raising Tg to 100^{o}C–120^{o}C range. Another potential issue is that the spider chart may be masking some of the properties. To demonstrate the CFRP to be usable for vehicles, the team needs to consider various tests to satisfy the safety requirements of OEMs.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

This reviewer said that the NREL team showed extensive collaboration from academia, industry and the national laboratories.

Reviewer 2:

It seemed to this reviewer that there are internal collaborations with NREL's project Bio-Optimized Technologies to keep Thermoplastics out of Landfills and the Environment (BOTTLE) or other projects, but that there is limited collaboration outside of NREL.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer believed that the development of the thermoforming approach has the promise to expand the range of applications beyond that of resin infusion and would provide more flexibility in material processing. Scale up of operations will also provide further data to determine the type and cost of capital infrastructure required for implementation in the field.

Reviewer 2:

This reviewer noted that the team will be able to meet the planned milestones. The reviewer believes, however, that it will be more beneficial to meet a very clear target of mechanical properties as well as stability to satisfy the stringent requirements for vehicle parts.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer found that the work reported is aligned with the VTO mission statement.

Reviewer 2:

This reviewer considered that the project scope (bio-based resins as well as covalently adaptable networks) is highly relevant. This is one of the best ways to transform CFRP technology toward low carbon and circular technology.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The team appears to this reviewer to have staffed the project sufficiently to complete all milestones and deliverables within the timeframe of the original project proposal.

Reviewer 2:

This reviewer opined that the team has good resources to conduct all the experiments, LCA and TEA, and will be able to execute all the planned activities.

Presentation Number: MAT210
Presentation Title: A Novel Manufacturing Process of Lightweight Automotive Seats – Integration of Additive Manufacturing and Reinforced Polymer Composite
Principal Investigator: Patrick Blanchard (Ford Motor Company)

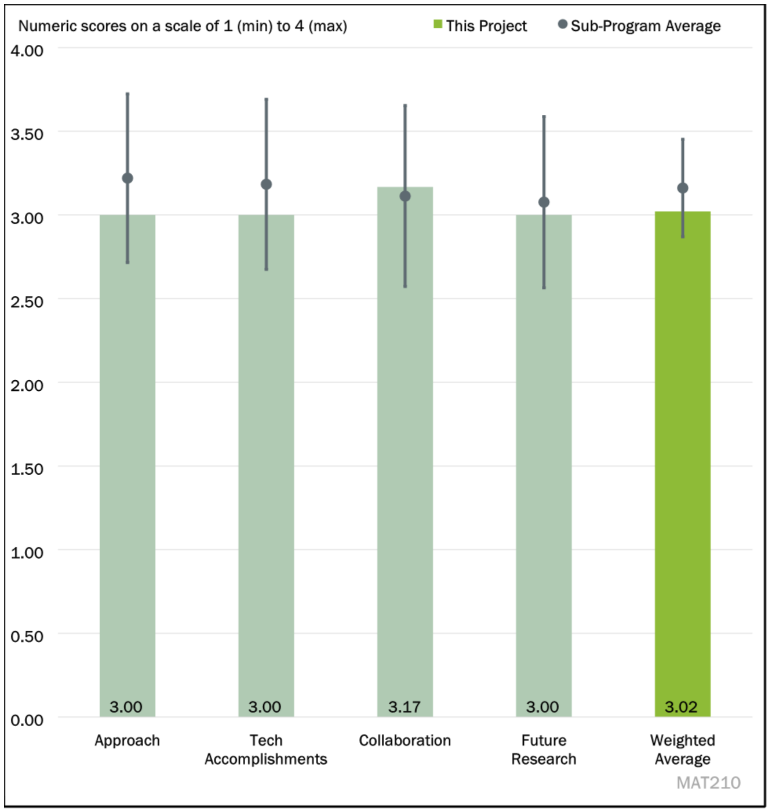

Figure 5-44 - Presentation Number: MAT210 Presentation Title: A Novel Manufacturing Process of Lightweight Automotive Seats - Integration of Additive Manufacturing and Reinforced Polymer Composite Principal Investigator: Patrick Blanchard (Ford Motor Company)

Presenter

Patrick Blanchard, Ford Motor Company

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

According to this reviewer, the proposed approach is very good and the integration with Ford is outstanding. The reviewer states a personal view that AM is not compatible with automotive manufacturing rates and believes that this work has shown that to be true.

Reviewer 2:

This reviewer found the work plan to be appropriately scoped and well executed, taking advantage of Ford baseline experience and ORNL expertise in AM to effectively craft a nice demonstration project integrating modeling and some materials evaluation along with demonstrating manufacturing processes. The reviewer is unclear as to whether the project had defined quantitative goals to measure against. Although in-line sensor integration and smart systems work were identified in the objectives of the project, there was no discussion of that work being performed during the currently completed project – just mention of these items for future work.

Reviewer 3:

This reviewer considered the approach to develop composite structures integrated with AM is good. The project attempted to address the technical barriers as listed. However, the reviewer is unclear as to whether the technology demonstration was purely virtual or involved tangible demonstrations at the component/seat back level. The control of fiber orientation in making the AM preform was mentioned, but no details were provided regarding how the orientation information was determined. The reviewer believes that the AM material was co-molded with CF material. The reviewer raises the question about any concerns regarding corrosion.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer pointed out that, although delayed by COVID, efforts coalesced well to demonstrate a route to increasing stiffness while reducing weight in the demonstration article. (It might have been even more impressive for the reviewer if the demonstration article had been tested as planned.) This reviewer appreciated hearing the candid assessment of status of the technology readiness vis-à-vis near-term production insertion, notwithstanding the showing of an enhanced structure using the novel approach.

Reviewer 2:

The reviewer commented that the team has made good progress although the development has shown the cost savings per pound are very high.

Reviewer 3:

This reviewer reported that the average stiffness determined from the samples is around 9.1 GPa (Slide 6), and the strength is 76.4 MPa (Slide 7). These values are very low compared to a commercially-available sheet molding compound, which would perform better and be cheaper. The reviewer asks, therefore, why this material was chosen to integrate with AM materials for the seat back. The stiffness of the composite seat back with a fully filled interior space and metal insert is around 930 N/mm (Slide 10). These values are lower than the metallic design (1100 N/mm), raising doubts for the reviewer as to whether this composite design has met the requirements. Overall, the reviewer believes that reducing the weight by 1.7 kg is good; however, the price increase per kilogram saved of $90.5/kg is very high and the reviewer asks whether there are any plans to reduce this price increase.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

Although the reviewer felt that interfaces and interactions were not fully defined in the presentation, the reviewer believes that the collaboration went well regardless of the severe COVID-related perturbations. The reviewer considers this work to be a good example of effectively introducing laboratory R&D into a real-world application for assessment of technology capabilities versus readiness.

Reviewer 2:

The team is very strong, according to this reviewer.

Reviewer 3:

This reviewer offered praise for good collaboration between Ford and ORNL.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer pointed out that the project is complete so the future research description would require follow-on funding to be proposed later. The items identified are considered by the reviewer to be definitely worthwhile but are more directed to providing longer-term research data than pointing towards addressing roadblocks in implementing the demonstrated approach into production.

Reviewer 2:

This reviewer noted that the project has been completed.

Reviewer 3:

This reviewer observed that no future work was proposed as the project was completed.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer believed that the project provides good insight into possibilities for enhancing performance and reducing vehicle weight along with assessment of the TRL for implementing this approach into production.

Reviewer 2:

Lightweighting is believed by this reviewer to be critical for future vehicles.

Reviewer 3:

This reviewer stated that the project is very relevant in developing new materials for lightweighting and increasing the efficiency of the transportation sector.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer noted that an effective technology demonstration has been completed. Perhaps with more funding, the demonstration article could have been tested, but it is not clear that data would have changed future work in this area.

Reviewer 2:

This reviewer found that the project was completed with the resources provided.

Reviewer 3:

This reviewer concluded that the project had sufficient resources for executing this project.

Presentation Number: MAT211
Presentation Title: Sustainable Lightweight Intelligent Composites (SLIC) for Next-Generation Vehicles
Principal Investigator: Masato Mizuta (Newport Sensors, Inc.)

Presenter

Masato Mizuta, Newport Sensors, Inc.

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

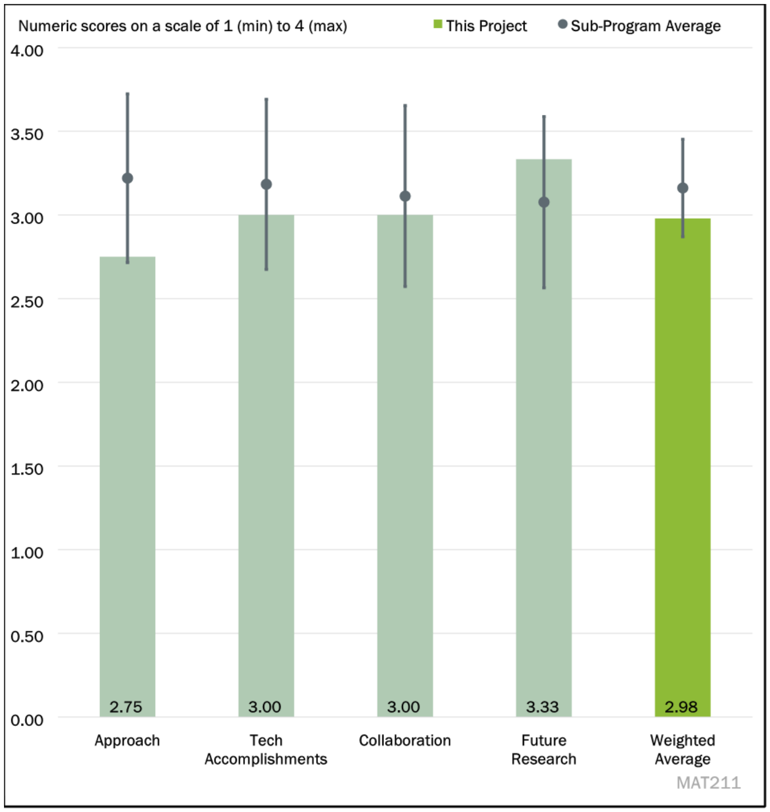

Figure 5-45 - Presentation Number: MAT211 Presentation Title: Sustainable Lightweight Intelligent Composites (SLIC) for Next-Generation Vehicles Principal Investigator: Masato Mizuta (Newport Sensors, Inc.)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The technology for damage detection appeared to this reviewer to require wide coverage or integration of sensors across a large area to be effective. For this to be practical, the researchers need to address the potential cost ramifications. In addition, the reviewer holds that, while use of a natural fiber core may offer some mass savings, there is no way of knowing the robustness of these materials in hostile service environments. Trimmed parts would need some form of edge protection in order to mitigate moisture ingress.

Reviewer 2:

This reviewer described how, in this project, a sensor is developed with natural fiber core and CF-hybridized strain monitoring sensor skins. The team has demonstrated the sensitivity of the sensor for tensile, flexure, and impact loading. The work aims to develop sustainable solutions. Overall, the studies have focused on static loading conditions. The work is largely conducted at a coupon level. The pathway for adoption by OEMs is not clear to the reviewer although the presenter mentioned that an OEM may be interested.

Reviewer 3:

The technical barriers and challenges were clearly outlined and addressed for this reviewer. However, the reviewer did not see much novelty in the use of a surface-adhered PVDF sensor integrated with a strain sensor on the surface of a CF composite with a natural fiber core. PVDF sensors have been previously demonstrated as sensing elements that can be adhered to the surface of composites. Additionally, this type of sensor adds weight to the composite without contributing any mechanical benefits, so they do not necessarily contribute to the lightweighting effort for vehicles.

Reviewer 4:

This reviewer pointed out that the project uses two types of sensors (static and dynamic). However, the reviewer was unclear as to why both are needed. In other words, the necessity of using two sensors within a single part was unclear to the reviewer. The response of both sensors was limited to the applied location, and therefore to observe the health of the whole structure, the whole structure or multiples of these sensors would be required. A cost analysis is required.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer pointed out that the robustness of using natural fibers for a bumper application will need to account for weather exposure and any potential failure modes. Furthermore, the team did not present any methodology for making rapid connection to the embedded sensing. This will be a requirement for any type of final implementation.

Reviewer 2:

The team accomplished all milestones in a timely manner, according to this reviewer. However, the reviewer believes that more sensor data could have been presented to show the effectiveness of the sensors. More data are needed to prove that the sensors will work in real-world scenarios.

Reviewer 3:

This reviewer referred back to some of the points mentioned above as applying to progress made. The team calls the sandwich construction natural fiber core and carbon/sensor skins as the novel sustainable lightweight intelligent composites technology and claims enhanced crashworthiness. Overall, the scientific approach of the work is very good and systematic. The challenge, according to the reviewer, will be implementation on a large scale. As an example, the water ingression, long-term durability, adhesion to the substrates, the form that the sensor will deliver for a structure (number, size, placement), measurement control unit (location, placement), and cost are unknowns at this point. The value of the work will be truly realized when all these questions get addressed. Presently there are many sensors on the market, and the utility of this technology (besides having a natural fiber core) was not fully clear to the reviewer.

Reviewer 4:

This reviewer found that the project successfully demonstrated that both types of sensors could be applied to composite structures for structural health monitoring, and preliminary data supports the hypothesis of early damage detection.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer stated that the team has reported adequate collaboration across the team. However, moving forwards, the team should seek guidance from potential Tier 1 and OEM partners regarding a more comprehensive set of requirements.

Reviewer 2:

The team established a good collaboration with the University of North Texas to the satisfaction of this reviewer and the reviewer believed that a lot of work was performed at the university. The collaborative effort can be improved if the team had a tier-one supplier or OEM involved to demonstrate commercialization.

Reviewer 3:

The collaboration identified by this reviewer is between Newport Sensors and the University of North Texas. The testing/characterization is largely conducted by the university and the sensor development is by the company. The reviewer believes this is good, but the identification of the tier 1/OEM's statements are rather vague, so this remains a weakness in this project.

Reviewer 4:

This reviewer found that there is additional scope to improve collaboration and work with some leading OEMs. On Slide 14, the presenter mentions that the team has reached out to multiple OEMs and Tier 1 suppliers. The reviewer would be interested in seeing how these interactions could be turned into tangible collaborations in the near future.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer indicated that the work to date does not address any concerns related to cost. Therefore, a detailed understanding of the TEA will be essential to validate commercial feasibility of any proposed application.

Reviewer 2:

This reviewer thought that the remaining challenges and barriers were clearly discussed. The team plans on fabricating a small-scale bumper beam for demonstration purposes was good. As proposed, the manufacturability and TEA are crucial to understand the commercialization feasibility for this technology.

Reviewer 3:

This reviewer noted that the project is ending in August 2023. The team indicated that some of the compression molding trials will take place through a future Small Business Innovation Research (SBIR) grant. Hence, the reviewer considers the future work question to be not appliable.

Reviewer 4:

The reviewer stated that the project aims to demonstrate the technology to more significant automotive parts (e.g., bumper beams). Applying these sensors to curved surfaces or more complex geometries than flat surfaces will be great because most damage initiation occurs from the highly stress-concentrated regions.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

According to this reviewer, maintaining the structural integrity and health monitoring of composite structures is essential to create confidence in the composite systems for load-bearing applications.

Reviewer 2:

The project provides an approach to strain monitoring and impact detection, according to the reviewer. However, the total cost of implementation is unclear to the reviewer and a broad array of sensors may be needed to detect localized damage to components. This could render the technology too expensive for automotive applications due to on-going cost constraints.

Reviewer 3:

This research is relevant for tracking damage within a composite, but it adds weight to the system, which goes against the VTO's objective of lightweighting. Using a natural fiber core can serve the lightweighting objective, but the focus of this work seemed to be on the sensing aspect, which adds weight to the system.

Reviewer 4:

This reviewer said that, while the work applies to materials, electrification, and energy savings in general, the development is actually more on the sensing side.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer confirmed that sufficient resources have been deployed to progress the project towards the final milestones and deliverables.

Reviewer 2:

The team has had sufficient resources to conduct this project, according to this reviewer.

Reviewer 3:

This reviewer considered that the project has sufficient resources to achieve the proposed goals.

Reviewer 4:

This reviewer found that the resources are sufficient to achieve the milestones of the project. The reviewer observed that the funds are almost excessive to achieve the milestones.

Presentation Number: MAT212
Presentation Title: Integrated Self-Sufficient Structurally Integrated Multifunctional Sensors for Autonomous Vehicles
Principal Investigator: Amrita Kumar (Acellent Technologies, Inc.)

Presenter

Amrita Kumar, Acellent Technologies, Inc.

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

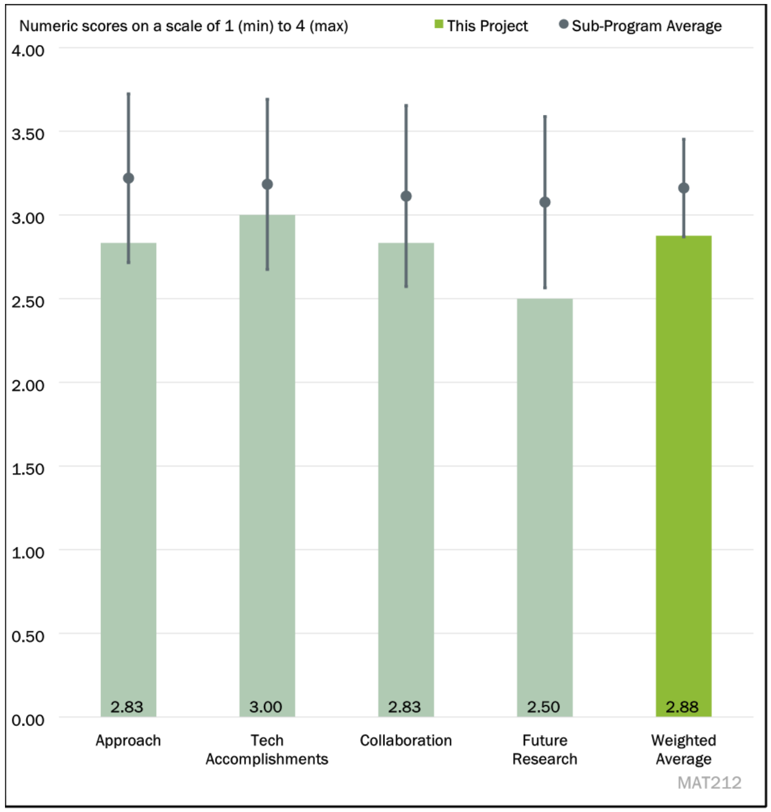

Figure 5-46 - Presentation Number: MAT212 Presentation Title: Integrated Self-sufficient Structurally Integrated Multifunctional Sensors for Autonomous Vehicles Principal Investigator: Amrita Kumar (Acellent Technologies, Inc.)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer found that the team took an innovative approach to instrument a plastic bumper with accelerometers and then train the control system to identify a unique signal as part of the pedestrian protection system. There remains a concern by this reviewer that false positive recognitions (such as an animal strike) or false negative recognitions could endanger passengers or pedestrians. Additional sensor information (including low-cost vision systems) integrated with the novel accelerometer data could improve the overall effectiveness of such a device. The team could have done a better job comparing the advantage of the battery state-of-health monitoring system vis-à-vis traditional fault monitoring using conventional voltage/amperage monitoring circuits. A clearer picture of methods used to determine the state of health would be useful to the reviewer.

Reviewer 2:

This reviewer determined that some progress has been made in the project in overcoming the barriers and meeting the proposed technical targets. The development of multifunctionality in composite materials is critical for reducing the overall cost at the system level, and this project attempted to achieve that by developing a pedestrian crash sensing system to detect impacts occurring on the front bumper.

Reviewer 3:

The reviewer pointed out that the project relies on contact-based detection. This form of detection is believed by the reviewer to be already too late to deploy in any current passenger protection system. For example, the vehicle's speed and the size and weight of the object (human) that gets hit will have a different response. Not everything that will get hit with the bumper will fall on the bonnet. Therefore, this project has many assumptions, and practical success is highly limited to some scenarios of crash/pedestrian protection system and would have been more impactful to have non-touch-based system.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The research team appears to this reviewer to have accomplished the tasks identified in its project proposal. Further test data collected for the proposed battery monitoring system is anticipated and should provide a better picture of the utility of the state-of-health monitoring and relate to battery performance and state of charge.

Reviewer 2:

This reviewer described how preliminary data suggest that the sensor can detect the difference in single peak frequency of pedestrian and non-pedestrian objects. Therefore, the technology has the potential to detect the pedestrian in certain experimental conditions. More experimental variables need to be studied to build a credibility of the current technology.

Reviewer 3:

The reviewer was unclear as to whether pedestrian and non-pedestrian impacts are determined based on the peak frequency measured at the piezo sensor, and, if so, whether this is true for all the sensors located on the bumper, as well as what characterizes the low peak frequency for non-pedestrian objects. On Slide 13, the presenter mentioned that novel energy methods were developed to classify pedestrian and small animal objects. The reviewer considers that providing more details would be helpful. Regarding battery monitoring, the presenter did not explain how the signal envelope becomes smaller when the state of charge is lower or at what frequency these guided waves need to be used. It is also unclear whether the piezoelectric sensors are located on the pouch cells and, if so, whether they are bonded to the pouch cells. The multi-functional energy storage composite skateboard shown on Slide 18 is a combination of composite and battery. The reviewer was unclear as to what was demonstrated on this slide regarding the multifunctional ability of composites. On Slide 19, the reviewer is not clear what $\alpha 1$ and $\alpha 2$ represent. Overall, the progress was expected by the reviewer to be more significant.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

This reviewer applauded good collaboration between Acellent, Ford, and Stanford University.

Reviewer 2:

This reviewer noted that although project partner, Ford Motor Company, is named and the bumper instrumented appears to the reviewer to have been sourced from Ford, there is little information provided in the reporting that suggests significant interaction between the two organizations. Similarly, there seems to the reviewer to be no relationship between the reporting team and Ford related to the battery monitoring system, which integrated a relatively small storage system consisting of ten cells used to power a skateboard. No specific scaling to an automotive or analogous battery system is referenced. This could impact the ability to commercialize the technology to full-scale automotive systems, according to the reviewer.

Reviewer 3:

The contribution of the other partner was not clear to this reviewer, who also feels that a better explanation of the work scope of each partner is needed. Stanford is working under a different funding program. The link between this work and Stanford's work is not clear to the reviewer.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer said that the proposed future work was not clearly provided in the AMR report. The reviewer believes that the functionalities of state-of-charge and state-of-health will be studied, but how this will be accomplished is not mentioned.

Reviewer 2:

This reviewer pointed out that there was no slide on future work, possibly because the project is on the verge of completion.

Reviewer 3:

This reviewer recounted how the team reported that 80% of the work on this project is complete (in June 2023) and the end date of August 23, 2023, is identified for completion. There was no proposed future work identified in this review or any gaps identified that need to be addressed in future work. This, the reviewer considers to be a shortcoming of the project whether the remaining 20% level of effort to be completed is addressed or (more importantly) suggestions for effort needed to commercialize in a potential Phase III technology commercialization phase.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer believed that the proposed project supports the overall VTO objectives of developing multi-functional capabilities of materials to increase efficiency in the transportation industry.

Reviewer 2:

This reviewer indicated that the relevance is modest, but creating and demonstrating integrated sensor technology is important for future automotive materials, where incorporating functionality in the form of embedded systems will enable extended capability and bring greater value to these advanced materials.

Reviewer 3:

This reviewer pointed out that the project aimed to develop a battery monitoring system for EV cars. The innovative battery management system will provide information on the state-of-charge and state-of-health of batteries with high precision. As far as the reviewer understands, the pedestrian protection system is not directly related to VTO objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer affirmed that the project has adequate resources in executing the project.

Reviewer 2:

This reviewer determined that the project has sufficient resources to achieve the proposed goals.

Reviewer 3:

Based upon the accomplishments reported by the principal investigator, this reviewer understands that funding/resources were sufficient to complete the objectives of the program. Additional funds might have allowed for a more realistic (at scale) build of a higher capacity batter system for the state-of-health monitoring, but the reviewer opines that this first step to demonstrate the system capability was likely a prudent approach.

Presentation Number: MAT221
Presentation Title: Lightweight and Highly-Efficient Engines Through Al and Si Alloying of Martensitic Materials
Principal Investigator: Dean Pierce (Oak Ridge National Laboratory)

Presenter

Dean Pierce, Oak Ridge National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

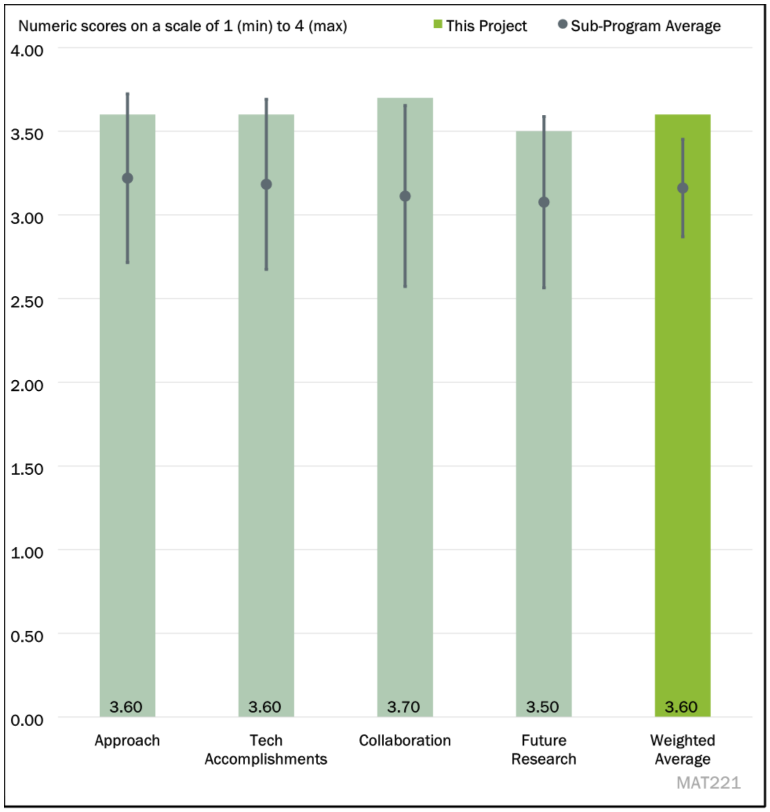

Figure 5-5 - Presentation Number: MAT221 Presentation Title: Lightweight and Highly-Efficient Engines Through Al and Si Alloying of Martensitic Materials Principal Investigator: Dean Pierce (Oak Ridge National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer considered that the key target for the project was optimization of the strength, thermal conductivity, and oxidation resistance of engine alloys. The project included use of computational modeling and experiments to develop new compositions. Finally, the technology performance was demonstrated on engine prototypes. According to the reviewer, the progress and deliverables for the project have been quite impressive.

Reviewer 2:

This reviewer pointed out that the project is addressing the heavy-duty vehicle sector to improve the state-of-the-art diesel engines to enable efficient use of lower carbon fuels. This is needed since the heavy-duty vehicle sector is difficult to electrify, with significant trade-offs occurring between battery weight, payload weight, and vehicle range. As such, the work being done by the ORNL lead team is needed to help with the introduction of low carbon fuels in over-the-road trucks. Using alloys can increase strength and provide oxidation benefits but results in a decrease in thermal conductivity, which raises piston temperature. The project is attempting to identify and optimize the properties of piston crown steels, which are machinable and weldable and are at an acceptable price point. With peak cylinder pressures and temperatures in the piston exceeding 500°C (the performance limit of 4140 alloy) to obtain higher efficiencies with low carbon fuels, new piston materials are needed to operate in these more severe engine conditions. A two-phased approach to take laboratory developed material to industrial scaleup is being used by the ORNL-led team. Leveraging the integrated computation materials engineering (ICME), laboratory scientists designed approximately 35 alloys that could withstand the conditions encountered in these higher temperature engines. The best candidate alloy was identified (G3-5M). The 4-year structure to bring the materials from start of the research to a commercially ready product can be used as a roadmap for other material development projects.

Reviewer 3:

This reviewer said that the project is very well designed to allow development and engine testing of piston prototypes. The first 2 years focused on laboratory scale research and the last 2 years are focused on industrial scale up.

Reviewer 4:

This reviewer appreciated the clear approach presented, starting from computational exploration to creation of industrially sized heats and experimental evaluation.

Reviewer 5:

This reviewer, noting that a 500-hour soak at 600°C revealed a reduced margin of improvement over 4140 when compared to an “as-fabricated” state, questioned whether long-term stability might be a concern. Heavy duty diesel engines would be expected to operate at high temperatures for an order (and possible multiple orders) of magnitude longer than 500 hours. The computational design component (prior to the down-selection of G3-5M) was not at all clear to the reviewer, who questions what iterations were being examined, what were the specific characteristics and cut-offs for these properties, and what methods facilitated this analysis.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer praised the project as again showing the value of the ICME and the ability to develop new materials needed for higher efficiency operations in both combustion and electrical systems. G3-5M was tested to document the key material properties needed for higher piston temperatures. An 85% increase in strength was demonstrated over 4140 steel at 600°C, along with a 28% increase in strength over H11 (5Cr tool steel) despite much lower alloy content. According to the reviewer, high cycle fatigue is more important than high tensile strength for the piston application. G3-5M showed 107% increase versus 4140 and 30% increase versus H11 in fatigue strength at 600°C after aging at 600°C for 500 hours. G3-5M extends the oxidation resistance at 600°C and demonstrated modest increases in thermal conductivity over H11. Sulfur was added to G3-5M to improve machinability. The challenge remains to replicate these results on scale-up.

Reviewer 2:

This reviewer described how prototype pistons have been manufactured and engine testing with full scale pistons made of the new alloy has been completed. New G3-5M alloy exhibits significant increases in strength (85%), extends the oxidation resistance over 4140 and has modest increase in thermal conductivity over H11 alloys. The G3-5M piston survived a modified peak power output test with enhanced severity in a Cummins X15 X600 production engine.

Reviewer 3:

This reviewer pointed to great laboratory-scale work and microstructural characterization and found that utilizing the split test for direct comparison is extremely compelling.

Reviewer 4:

This reviewer noted that the team had designed and tested a promising alloy that seems to provide improvement over baseline materials.

Reviewer 5:

This reviewer noted that the project successfully achieved the project milestones. The properties achieved for the new alloy composition have been very impressive. The piston prototypes survived the aggressive engine testing. The results from engine oxidation tests, however, were not presented.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

This reviewer lauded that the alignment of the project team with a national laboratory lead, ORNL, enables it to leverage unique capabilities from experience with other related projects under Thrust 4 to maximize the investment made by DOE. ORNL is also setting in place the mechanisms needed to commercialize this technology as it develops cooperative R&D agreements (CRADAs) with industry partners. These arrangements are critical to bring this technology to the commercial marketplace. The CRADAs between Cummins and ORNL and the partnership established with Mahle (both industry leaders) sets the groundwork for the transition to commercialization.

Reviewer 2:

This reviewer praised how the strong ORNL team is highly complemented by the addition of a Tier 1 (Mahle) manufacturer and a Tier 1 company that has many of the characteristics of an engine manufacturer OEM (Cummins).

Reviewer 3:

This reviewer noted that the project is being carried out through a CRADA between ORNL and Cummins with piston manufacturing partner Mahle.

Reviewer 4:

This reviewer pointed out that the main gap identified by the researchers was in finding a prospective steel mill for larger production volumes.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer said that the future work is clearly presented, suggesting, however, that it would be natural for the commercial partners to support the suggested activities. The reviewer was interested to know if there had been any interest from the OEMs/suppliers for investing in it and commercializing/licensing the technology.

Reviewer 2:

This reviewer listed tests to be completed on fatigue, wear, and laboratory scale oxidation. The team will fine tune the chemistry if needed to address any required systems performance improvements in components that are needed during low compression fuel combustion.

Reviewer 3:

This reviewer found that the proposed future research plan is well laid out and seems very feasible, given that the project is in its 4^{th} and last year. Remaining tasks include characterization of engine tested pistons in addition to fatigue, wear, and oxidation testing, as well as developing a detailed final report.

Reviewer 4:

This reviewer identified the future research as mostly composed of closing out planned testing. Exploration of expansion into other applications seems good to pursue if commercialization is possible.

Reviewer 5:

This reviewer was not convinced on the wear testing needs disagrees with the utility of thermal fatigue (past reviewer comment) on heavy-duty pistons for diesel applications. The reviewer concluded that the path seems appropriate.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer confirmed that the project is in line with VTO Materials subprogram objectives and is an industry CRADA with Cummins.

Reviewer 2:

This reviewer believes that the project is directly relevant to the VTO Materials subprogram objectives.

Reviewer 3:

This reviewer characterized the work as a classic performance problem being solved through materials R&D.

Reviewer 4:

This reviewer stated that the project identifies and addresses a near term gap in energy efficiency for heavy duty vehicles, which will likely remain dependent on fossil fuels.

Reviewer 5:

This reviewer opined that the project is relevant and important to the VTO, especially with regards to GHGs by operating the heavy-duty vehicle engines at higher temperatures and more efficiently. This is particularly important since electrification of heavy-duty vehicles with large payloads is still uncertain.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer noted that the budget includes only a $150,000 DOE contribution with $350,000 cost share from Cummins via the CRADA for a project with significant technical achievements.

Reviewer 2:

This reviewer believes that the project again illustrates the unique value of the ICME. This project has overcome material challenges encountered during high efficiency combustion. The performance characteristics of this alloy permit engine builders to adapt their engines to use low carbon fuels. The use of CRADAs should continue to be encouraged to allow industry to invest in this promising research. DOE should also identify other possible applications for this alloy and its unique performance characteristics.

Reviewer 3:

This reviewer thinks that the resources seem adequate, noting that not a lot of time remains if extensive fatigue testing is planned.

Reviewer 4:

This reviewer commented that there are no limits to the successful completion based on resources identified.

Reviewer 5:

This reviewer said that the project funding for the laboratory seems to be fine.

Presentation Number: MAT222
Presentation Title: Extending Ultrasonic Welding Techniques to New Material Pairs
Principal Investigator: Jian Chen (Oak Ridge National Laboratory)

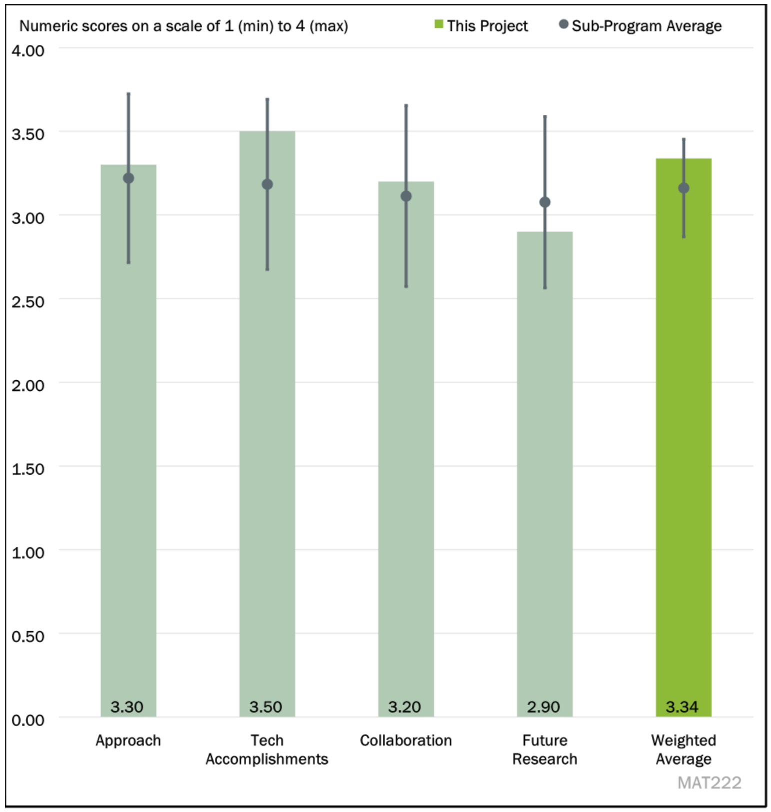

Figure 5-6 - Presentation Number: MAT222 Presentation Title: Extending Ultrasonic Welding Techniques to New Material Pairs Principal Investigator: Jian Chen (Oak Ridge National Laboratory)

Presenter

Jian Chen, Oak Ridge National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer found the project approach, which includes a model-based engineering strategy to guide the development of a novel ultrasonic welding (USW) process using *in situ* measurements, post-weld characterizations and modeling to be a good one.

Reviewer 2:

This reviewer commented that substantial effort has been placed on evaluating the process of USW. This includes finding relationships between process parameters and mechanical performance and developing creative *in situ* measurement techniques. One important barrier of translating parameters determined on single joints to multiple joints has been addressed.

Reviewer 3:

This reviewer shared that the project does a nice job of surveying various techniques using USW to address the problem of multi-material joining. The results for all materials combinations appear promising. Since the last review, the researchers have established a close-looped processing parameter set to make multiple joints in a row, based on thermal characteristics that align with button size. The demonstration showed that this technique can work on different material stack-ups for a line of welds. Given the use of thermal characteristics, a demonstration of using the USW control approach using different thicknesses of sheet material would have been useful to see. The ultrasonic rivet joining (URJ) approach was an important addition to extending this technique to CF reinforced polymers (CFRP) joined to Al. The selected materials were appropriate for the study and the results look promising.

Reviewer 4:

This reviewer noted that the original objective was to extend USW from coupons to multi-weld components. In the first year, a directional effect (longitudinal vs transverse) was noted but neither the underlying physics nor how it could be taken advantage of was investigated. This seems to the reviewer to be a missed opportunity, especially when considering the constraints imposed on multi-joint structures. In year 3 an *in situ* characterization technique was developed which the reviewer finds very interesting. In fact, the reviewer sees an opportunity to apply that to further investigate this directionality issue. The project, however, focused on expanding to multi-material combinations, which corresponds to a quite specific objective stated in year one vs a more general objective stated for years two and three. The corrosion aspect is a good opportunity for collaboration, but since it was not originally planned for and was included in the reports, the reviewer is concerned that the budget which could have further advanced the stated project objective was spent on that. The expansion to CFRP/Al joints was included in the original planning but because this project did not include a clear manufacturing readiness level (MRL) as part of the objective, the reviewer finds it is not possible to make a comment on planning to this effect. For example, an issue of the horn design was highlighted but it was not made clear what the fundamental issue was leading to this problem. Regardless, the reviewer believes that the interaction of horn design and quality should be further investigated.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer noted that significant accomplishments in the least year include *in situ* interface characterization of USW, joining immiscible Mg to bare steel, a predictive tool to correlate temperature with joint strength, new model-based approach to determining process parameters for welding large coupons, and a patented URJ approach to join metal/polymer.

Reviewer 2:

This reviewer stated that the technical progress is aligned with project plan.

Reviewer 3:

This reviewer pointed out that the team has accomplished quite a bit, particularly in the USW control study.

Reviewer 4:

This reviewer found that most targets have been achieved or are on track but does not see, however, a close interaction with the industry.

Reviewer 5:

This reviewer commented that the project has covered a significant amount of ground and made significant progress towards overcoming the issue of extrapolating the USW process from a single coupon to a multi-weld joint. For example, the team states that it has developed a very different and innovative approach to monitoring and controlling the USW process to ensure consistent joint strength and quality under different pitching distances and locations of multiple spot welds at the part/component level. Unfortunately, the presenter does not provide a clear explanation of what that process is. For example, the presenter states that the process consistently monitors process signals and gives a diagram with a “sensor” on the sonotrode. Yet, the presenter then goes on to state that the predictive tool correlates temperature with joint strength. However, it is not explained how temperature is derived from the continuously monitored process signals. Despite this, the work on developing correlations of process and strength and defining good/bad welds based on threshold values is of great importance.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

This reviewer saw appropriate collaboration among partners by ORNL, the project lead, leveraging PNNL advanced electron microscopes and Argonne National Laboratory (ANL) advanced X-ray synchrotron source. The team also mentioned proactively engaging with the industry partners to further mature the process.

Reviewer 2:

This reviewer noted that contributions appear to be made and collaboration carried out by the partners.

Reviewer 3:

This reviewer commented that the partners seem well coordinated in the experimental work and the simulation work.

Reviewer 4:

This reviewer opined that the coordination is good between projects, giving as an example that this work is feeding the corrosion project which was a separate project in itself. However, it is unclear to the reviewer whether this diverted significant resources from this project’s stated goal. As a side note, since adhesive does provide an inhibiting role in corrosion, further work on the impact of wet adhesive at the faying interface on the USW process is necessary.

Reviewer 5:

This reviewer believes that closer contact and collaboration between the laboratories and also some collaboration with academia would be desirable. ORNL seems to perform most of the activities.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer found the identified future research to be appropriate, considering that project completion in Fiscal Year 2023 includes refining URJ process conditions with the new rivet and sonotrode design, as well as extending it to join large structures and achieve an average joint strength at least 80% of the reference strength obtained on single-joint coupons.

Reviewer 2:

This reviewer was concerned that a detailed plan for future work does not seem to have materialized. A look at different materials and a new sonotrode design are mentioned but details are not planned. Additional tasks may be to look at corrosion in detail and to develop at least one real-life application that would be undertaken with the industry.

Reviewer 3:

This reviewer finds that the focus on extending the URJ approach is great but thinks that there is a lot more work that can be done on the USW controls side in terms of stack-ups and extending the process to something more industrially capable.

Reviewer 4:

This reviewer stated that the project is nearly complete. The project did have clear go/no-go decision points outlined in the project plan. Because this project covered a significant amount of work, the reviewer recommends that the final project report detail the various technology questions identified and investigated and assign MRLs as well as what remains to be addressed to move the technology to the next level. This would strongly support off-shoots of additional projects and help industry understand the technology and potential opportunities.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer confirmed that the project supports the VTO materials subprogram objectives as it is investigating multi-material joints with two variants of ultrasonic welding to achieve vehicle lightweighting for improved energy efficiency.

Reviewer 2:

This reviewer believes that solutions to vehicle construction involve multi-material systems; joining dissimilar metals especially solid-state joining is very important.

Reviewer 3:

This reviewer said that development of a joining technology for multi-joint assemblies composed of lightweight materials addresses one issue for moving this technology towards industrial applications, whereupon its implementation would support mass reductions and thus reduction of GHG emissions in addition to increasing the range for EVs from those mass reductions.

Reviewer 4:

This reviewer found that the project is aligned with the Materials subprogram.

Reviewer 5:

This reviewer pointed out that multi-material joining is a key enabler for lightweighting technologies. This project uses extensive experimental work to provide a closed-loop way to change parameters quickly without advanced planning to address the weld button in a line of joints. It would be useful to see an industrial partner that could evaluate this technology for applications.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer believes that nearly $1 million in Fiscal Year 2023 funding seems appropriate for scope and accomplishments of this project which is ending in Fiscal Year 2023.

Reviewer 2:

This reviewer said that the resources seem to be sufficient; some work related to modeling of multi- joints and Al-composite multi-joints remain to be completed.

Reviewer 3:

This reviewer says that the project seems to have sufficient resources to deliver its objectives.

Reviewer 4:

This reviewer answered this question by stating that the year 1 presentation did not include a clear set of timing and deliverables, which would be reasonable for a low MRL project. However, if the MRL were higher, there would be an expectation that the resources were spread too thin and that more resources should have been provided and been more narrowly focused. Year 2 review clearly includes a Gantt chart of deliverables and timing, and the resources appear to be aligned with this plan given the body of work presented over the 3 years. Furthermore, this question cannot be answered without making some reference to the imposition of

COVID upon the original project plan and the ability to move the project forward while the team members were working remotely. To that point, the reviewer feels the team did an excellent job.

Presentation Number: MAT223
Presentation Title: Extending High Rate Riveting to New Material Pairs
Principal Investigator: Kevin Simmons (Pacific Northwest National Laboratory)

Presenter

Kevin Simmons, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

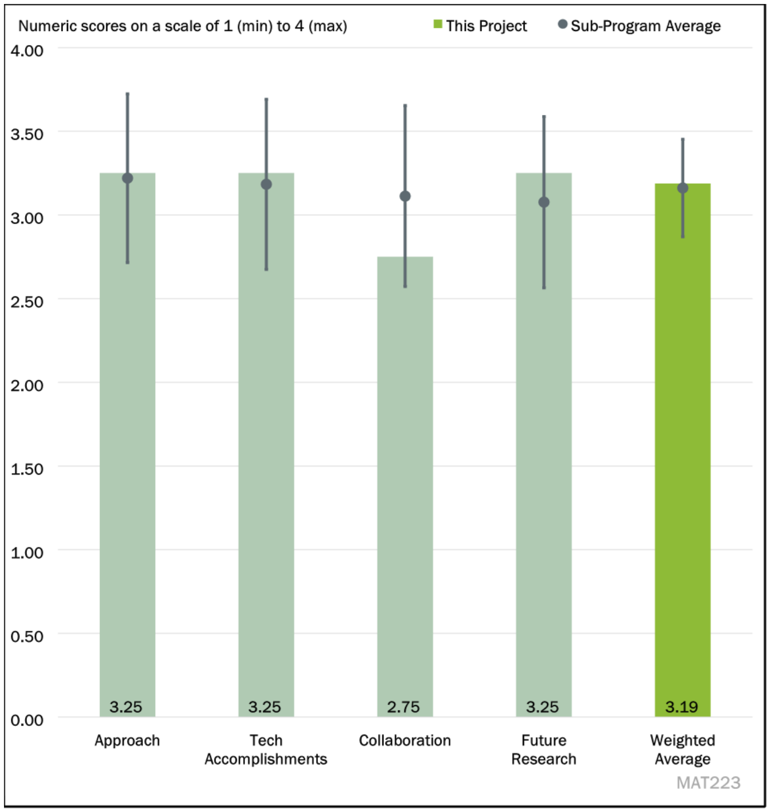

Figure 5-7 - Presentation Number: MAT223 Presentation Title: Extending High Rate Riveting to New Material Pairs Principal Investigator: Kevin Simmons (Pacific Northwest National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer acknowledged a good overall approach that includes surface modification, joining, and corrosion performance to correlate the effect of processing on joint microstructure and bond strength for high-velocity and high-rate friction rivets.

Reviewer 2:

This reviewer noted that the project is developing high-rate riveting processes (high-velocity riveting [HVR] and high-rate friction riveting), in some cases combined with adhesive bonding, to produce multi-material joints for lightweight metals and composites. One of the stated barriers is that “no high-fidelity models exist to aid engineers in joint and process design” which seems like a possible understatement of prior work. Perhaps a more accurate description of the barriers addressed by this project would relate to insufficient reliability/load carrying capacity in multi-material joints, where the project team seems to be making good progress.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer identified significant accomplishments in the last year that include determining chemical bonding at adhesive/substrate interfaces and plasma enhanced mode I fracture energy (330% increase) and lap sheer (200% increase) of CFRP joints. Progress was also made in laser texturing CFRP, resulting in a 7%

increase in lap shear. The team completed more than 150 tests, resulting in surface modified Al optimized for lap shear adhesion with HVR.

Reviewer 2:

This reviewer found that good progress is being made. Some of the noteworthy accomplishments include (1) the development of a sustainable lignin adhesive with 90% of the strength of the comparable thermoset adhesive and (2) demonstration of dissimilar Al-to-steel rivet joints with high load carrying capacities where the team is showing some substantial improvements.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

This reviewer found good collaboration among PNNL, ORNL and ANL to develop scalable and cost-effective processing methods to improve the properties of the joints in multi-material systems.

Reviewer 2:

This reviewer believes that most work seems to be happening at PNNL. ORNL’s development of the lignin-based adhesive was reported in two other project presentations (MAT 223 and MAT 225) and the reviewer was not entirely clear on where the funding came from to complete that aspect of the project. The industrial partners are engaged in relatively small roles as material advisors. Enhanced connections (perhaps present but not emphasized) could tie together the various aspects of the project more strongly.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer determined the proposed future research to be appropriate, given that project completion in Fiscal Year 2023 includes additional mechanical tests and detailed microstructural characterization to understand the joint behavior and continued collaboration with the modeling team to simulate process development for stronger joint performance.

Reviewer 2:

This reviewer pointed out that the 3-year project is planned to end in September 2023 (3 months after the peer review). Milestones are weighted towards the project end. Two of six milestones have been completed, meaning that there are still 4 milestones outstanding, suggesting a possibly challenging schedule. The Future Work slide focuses on high-rate friction riveting, leading the reviewer to question whether any work is still being done on the other joining methods including HVR.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer affirmed that the project supports VTO materials subprogram objectives as it is investigating multi-material joints with high-speed joining techniques to achieve vehicle lightweighting for improved energy efficiency.

Reviewer 2:

This reviewer determined the project is well aligned with DOE objectives in multi-material joining.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer opined that just under $700,000 per year funding over 3 years seems appropriate for the scope and accomplishments of this project, which is ending in Fiscal Year 2023.

Reviewer 2:

This reviewer assented that the resources are sufficient.

Presentation Number: MAT224
Presentation Title: Solid State Joining of Multi-Material Autobody Parts Toward Industry Readiness
Principal Investigator: Piyush Upadhyay (Oak Ridge National Laboratory/Pacific Northwest National Laboratory)

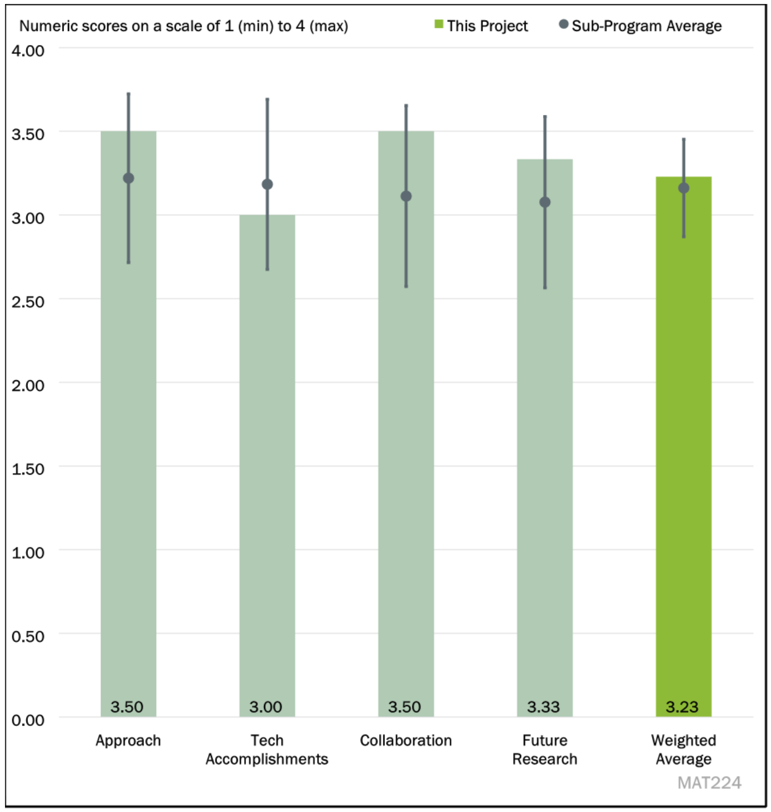

Figure 5-8 - Presentation Number: MAT224 Presentation Title: Solid State Joining of Multi-Material Autobody Parts Toward Industry Readiness Principal Investigator: Piyush Upadhyay (Oak Ridge National Laboratory/Pacific Northwest National Laboratory)

Presenter

Piyush Upadhyay, Oak Ridge National Laboratory/Pacific Northwest National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer found that the project is mostly on track, and, with a few exceptions, milestones are being met.

Reviewer 2:

This reviewer said that the project approach of evaluating two solid-state joining (friction stir welding and friction self-piercing rivet methods for multi-material components, including dissimilar Al-Al, Al-ultra-high strength steel, and Al-CFRP, and demonstrating viability and repeatability on a robotic platform is a sound one. The approach could be slightly improved by including Al-Mg, but, according to the reviewer, overall, this is a sound approach that seems to be well targeted for commercial application.

Reviewer 3:

This reviewer noted that the project is deploying friction stir welding for solid-state linear and spot joining of multi-material components to support lightweighting. The large-scale robotic platform implementation being pursued here is an important advance for scale-up of this method from coupon/lab scale to an automotive product application. The investigators have succeeded in this platform transition and are effectively handling scale-up challenges such as low bonding at the exit hole. The optimization approach for parameters such as dwell and plunge time is methodical and sound with steady improvements being made.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

Noting that the project deals with solving manufacturing related challenges and improving efficiency of joining processes, the reviewer points out that these are difficult to accomplish in laboratory settings. Nonetheless, PIs from two laboratories are co-operating and making reasonable progress.

Reviewer 2:

This reviewer found that the project has achieved good joining performance results with friction stir welding and friction self-piercing riveting. Furthermore, development of pilot hole and plunge-in parameters, as well as weld bonding performance evaluations, have resulted in further improvements. However, the tool life assessment, demonstrated predictability, process repeatability, weld fixture and fixture schemes, and the component fabrication and joining process demonstration and evaluation are all back loaded or delayed into the final six months of a 3-year project. This timing plan may be significantly underestimating the expected challenges in this phase, and it seems to the reviewer unlikely that this project will be completed on time. In fact, two and one-half years into a 3-year project, only two milestones have been achieved.

Reviewer 3:

This reviewer said that the technical achievements to date are very good, though there are some delayed milestones compared to the project plan.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer found excellent collaboration between national laboratories and industry teams.

Reviewer 2:

This reviewer held that the project effectively utilizes resources from two national laboratories along with automotive industry participation from Honda (providing material guidance and stack-ups as well as design and process requirements), Arconic (providing Al sheet materials), and Magna (providing Al stampings for the project demonstration phase).

Reviewer 3:

This reviewer was pleased that the collaboration between the two laboratories seems to be well coordinated and the industry partnerships, including with Honda, are valuable for the full-scale body-in-white/stamping studies.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer found that the proposed future research plans were satisfactorily presented.

Reviewer 2:

This reviewer considers that the proposed future research is appropriate and well defined to further improve on the work already completed and further support potential high-volume commercial application.

Reviewer 3:

This reviewer pointed out that the project is nearly complete (ends September 2023) and some milestones were delayed so it may be challenging to complete all of the outstanding milestones prior to project end. Some milestones are still noted as “future” rather than in progress, suggesting that work on these has not yet begun.

According to the reviewer, the purpose and value of the future work is clear. The work with stampings that include curvature will be important for demonstration of the range of capabilities of this weld technique, so hopefully this can be completed despite the challenges with other lead times noted.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer believes that joining is a critical technology for the lightweighting mission of the Materials program. The project supports this technology.

Reviewer 2:

This reviewer determined that the project supports the overall VTO materials subprogram objectives by focusing on development of cost-effective, fast, and reliable dissimilar metal joining technologies to enable improved integration of high-volume lightweight mixed material automotive sub systems.

Reviewer 3:

This reviewer affirmed that the project is well aligned with DOE objectives in multi-material joining.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer found the resources are sufficient.

Reviewer 2:

This reviewer considers that the funding for the project is substantial. However, the project objectives are substantial as well. The collaboration of two national laboratory teams along with three industry partners should result in a successful project, although there is some risk of going beyond the planned completion date.

Reviewer 3:

This reviewer said that the resources are sufficient.

Presentation Number: MAT225
Presentation Title: Surface Modifications for Improved Joining and Corrosion Resistance
Principal Investigator: Vineet Joshi (Oak Ridge National Laboratory/ Pacific Northwest National Laboratory)

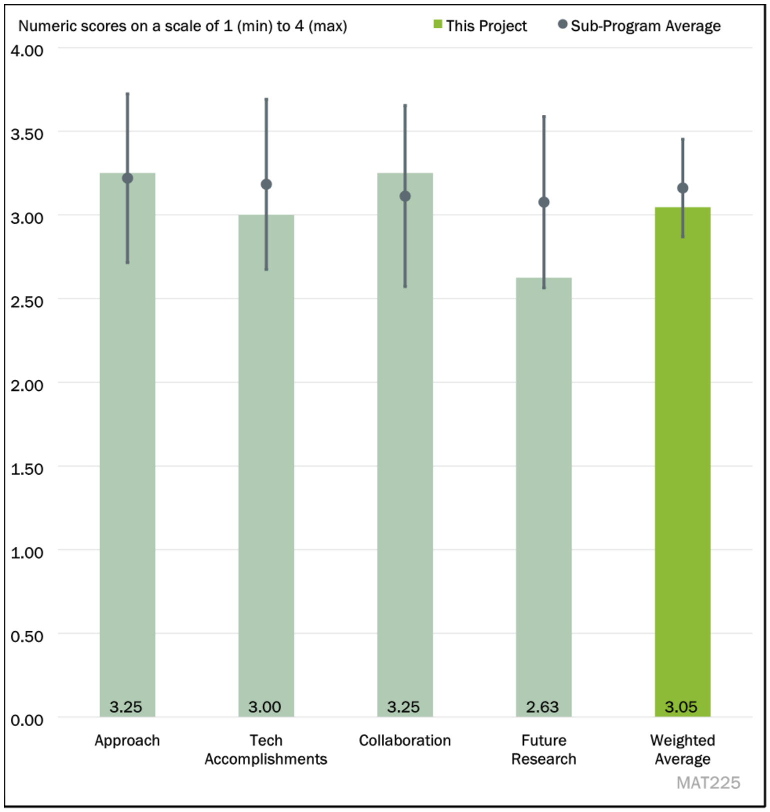

Figure 5-9 - Presentation Number: MAT225 Presentation Title: Surface Modifications for Improved Joining and Corrosion Resistance Principal Investigator: Vineet Joshi (Oak Ridge National Laboratory/Pacific Northwest National Laboratory)

Presenter

Vineet Joshi, (Oak Ridge National Laboratory/ Pacific Northwest National Laboratory)

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 50% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 50% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

According to this reviewer, the project has addressed technical barriers on corrosion resistance and joint strength using open air plasma-treatment, electric insulation on steel rivet to mitigate galvanic corrosion of dissimilar joints, and laser ablation treatment, along with introduction of an adhesive between joint plates to improve bond strength. All the adopted methods demonstrated a clear trend of improvement on the identified technical barriers. The team has designed all the testing plans reasonably to evaluate the effectiveness of proposed technical approaches.

Reviewer 2:

This reviewer points out that the project addresses barriers related to joining and corrosion resistance of multi-material combinations prone to galvanic corrosion and includes some impressive progress. However, the efforts seem to the reviewer to be a bit scattered in some areas and don’t seem quite as coordinated as they could be. For example, the addition of high velocity clinching was not discussed at all early in the project and there is no description as to what is different between high velocity clinching and conventional clinching to make it a more desirable joining alternative. It is not clear to the reviewer whether this process is better for less ductile materials. Furthermore, coach peel or cross-tension tests would be very valuable in fully understanding joint performance before and after corrosion testing since the failure mechanisms and behavior can be dramatically different than those for lap shear and/or double cantilever beam.

Reviewer 3:

This reviewer was concerned that the project appears to be driven more by the dissimilar material joining work of other projects than by deep diving the fundamentals of any corrosion inhibiting technology. However, this is in line with the objective to achieve three times greater joining life than for a given technology and, as such, addresses the technical barriers. Unfortunately, the advantages of the various corrosion inhibiting technologies may be distorted because of the experimental nature of the joining processes these were applied to. The reviewer feels that inclusion of a baseline commercial joining technology such as SPRs would have provided a substantial basis of comparison.

Reviewer 4:

This reviewer characterized the project as developing surface treatment methods to improve adhesion and reduce electrical conductivity to improve galvanic corrosion performance. Work includes experimental and COMSOL modeling. The reviewer is glad to see that the team has integrated saltwater exposure corrosion tests this year and is now also conducting experiments with an industry standard pulsed laser. The reviewer would find it helpful to see more quantification of saltwater corrosion performance improvements from surface modification.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer noted that the original objective is to produce high-quality, corrosion resistant joints with three times longer lifetime. Different levels of enhancement were achieved in different tasks. For instance, it was reported the resistance was improved by more than two times compared to untreated materials. It is unclear to the reviewer how much further enhancement can be achieved. Scale up of opener plasma treatment was achieved through introduction into a robotic system. Tasks originally planned to complete in March and June are all marked in progress. The reviewer suggests that an explanation on reasons for delay would be helpful.

Reviewer 2:

This reviewer is impressed by the technical accomplishments, especially with respect to the open air plasma work and the alumina-forming alloy steel rivets. However, it is not clear how the alumina-forming alloy rivet performance would compare to zinc-plated rivet performance, and the value of the results are ultimately limited by the weaknesses inherent in the dispersed project approach, according to the reviewer.

Reviewer 3:

This reviewer described how the project has developed analytical techniques to investigate surface interactions (such as chemical bonding) which can be exploited not only for this project but any related projects investigating surface processing for improved performance under environmental exposure. For example, the types of adhesives were extremely limited and not necessarily those which are heavily used in structural automotive applications. Furthermore, a novel oxide coating for rivets was developed, which exhibits significant promise. However, it would be advantageous to compare the performance of zinc-coated rivets which is a commercial standard as a baseline.

Reviewer 4:

This reviewer related how most milestones are completed or on track for completion. The milestones are primarily process-related deliverables. While these tasks are being completed more or less on schedule, the reviewer would have liked to see more quantitative specificity on the performance improvement targets embedded in more of the milestones of this project (e.g., reduce X by Y% rather than simply "demonstrate the minimization of long-term corrosion … by utilizing optimized surface treatment methods"). Especially for a project of this size, SMART milestones would make the tangible technical progress clearer, according to the reviewer.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

This reviewer believes that collaboration between the three laboratories and industry is well organized and utilizes strengths from each partner reasonably.

Reviewer 2:

This reviewer found that the group of participants (including three national laboratories, one automotive OEM, and one automotive adhesives supplier) seem to be well coordinated and focused on complementary tasks, so that the work of each informs the others and does not duplicate efforts.

Reviewer 3:

This reviewer determined that there is significant collaboration between the joining process projects and this project since this project is focused on application of surface modification techniques on these aforementioned joining technologies. The issue the reviewer sees is that the objective is a three times greater life over the baseline and since these joining technologies are currently undergoing development, it is difficult for the reader to understand what the baseline is.

Reviewer 4:

This reviewer believes that collaboration between the three laboratories is well coordinated, with monthly meetings and shared material batching for consistency. The involvement of industry is good; the scale and specifics of the General Motors (GM) partnership, however, are not totally clear to the reviewer, who feels that, without strong industry involvement, it could be difficult to get this technology scaled and out of the laboratory.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer suggested that more clarification would be helpful to understand to what extent adhesion bonding and corrosion resistance are expected in future work.

Reviewer 2:

This reviewer said that the proposed future research seems to be well planned to address the stated remaining challenges in the program, although they do not address some of the shortcomings related to joint strength testing.

Reviewer 3:

This reviewer ranked the proposed future research as fair based on the amount of funding remaining and the breadth of topics that the project team is proposing to investigate. The proposed future research topics are of significant technical importance. For example, the team proposes to refine the process for laser and atmospheric plasma modification of AA7075 and cast Al. The remaining budget is listed as 20% and process development for these two alloys and processes would seem to require a significantly greater level of engagement. It may be more prudent to identify a key question or hypothesis and then investigate that as an attempt to deep dive a singular topic which could help to achieve the three times life improvement.

Reviewer 4:

This reviewer pointed out that the project is nearly complete (ending 3 months after the AMR, in September 2023) and future work plans include process refinement, further evaluation of additional surface treatment methods, and more characterization and modeling. This is a wide range of activities for the short time remaining and the tangible benefits that will be gained from each activity are not completely clear to the reviewer, who would like to have seen more specificity here (targets) as well as further justification for the expected benefit from each of the planned experimental/characterization/modeling activities. The reviewer questions what will be learned from the planned testing, and how will this learning inform strategies to address the critical barriers. In the reviewer's view, the most valuable future work for the three months remaining would focus on developing clear, repeatable and benchmarked datasets quantifying the improvement gains from the most promising surface modification techniques developed in the project.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer affirmed that the project supports the subprogram objective on Materials by improving the strength and galvanic corrosion resistance of multi-martial systems in vehicles.

Reviewer 2:

This reviewer said that the project is relevant to the VTO Materials subprogram objectives as it is focused on developing surface modification techniques to optimize corrosion performance of dissimilar multi-material joints.

Reviewer 3:

According to this reviewer, corrosion of dissimilar material joints is a significant technical barrier to the industrialization of advanced joining technologies for just joints. Because of this, mass saving multi-material joints are not commonplace in the automotive sector and mass savings opportunities are missed. Mass savings is one path to a society having fewer GHG emissions.

Reviewer 4:

This reviewer confirmed that the project is well aligned with DOE objectives in multi-material joining and corrosion mitigation.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer noted that the whole project team is performing testing on the same batches of materials. Sufficient materials are planned for future tests and software licenses are available to the team for simulation tasks.

Reviewer 2:

This reviewer believes that the milestones of the project have been assessed as the team has defined them based on the available resources within this project as well as the opportunities for leveraging the experimental work of other projects. In that regard, the reviewer says that the team has done a good job in distributing the available resources to a broad scope of work. It is hoped by the reviewer that, at the end of the project, the final report contains not only a summary of what the project team has accomplished, but, more importantly, a roadmap for developing the surface modification technologies of interest to higher MRLs. For example, extrusions typically have a higher level of reflection of a laser beam than a cast surface. The reviewer would like to know how that might affect the refinement of laser surface modification and how might the distribution of alloying content within a casting affect the oxidation product. This project scratches the surface with the available resources so the reviewer would hope that the goal is to identify those specific technology roadblocks, i.e., technical questions which need to be answered in future work.

Reviewer 3:

Considering that this is a reasonably large project, the milestones, most of which are process-based and qualitative rather than performance-based and quantitative, don’t seem to this reviewer to be as ambitious or sharply focused as they could be for the resources available (funding level) for this project.

Reviewer 4:

While the project has achieved some impressive results, according to the reviewer, the scope of work does not seem to justify the substantial funding allocation provided for this project.

Presentation Number: MAT226
Presentation Title: Machine Learning for Joint Quality and Control
Principal Investigator: Keerti Kappagantula (Oak Ridge National Laboratory/Pacific Northwest National Laboratory)

Presenter

Keerti Kappagantula, Oak Ridge National Laboratory/Pacific Northwest National Laboratory

Reviewer Sample Size

A total of one reviewer evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

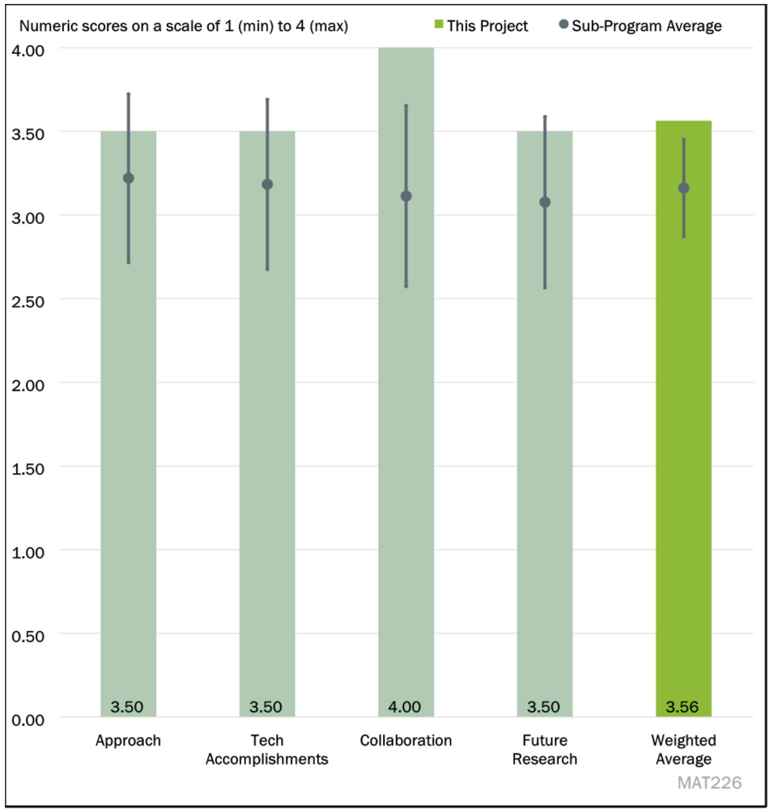

Figure 5-10 - Presentation Number: MAT226 Presentation Title: Machine Learning for Joint Quality and Control Principal Investigator: Keerti Kappagantula (Oak Ridge National Laboratory/Pacific Northwest National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer noted that the project leverages more than 30 gigabytes of spot-welding data (images and test data) from industry partner GM to develop machine-learning models that can be used for decision support and process optimization. The project is well planned and executed, according to the reviewer.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer points out that the project has about a year remaining in its period of performance and is generally on track or ahead of schedule. One milestone due June 30, 2022 (1 year ago) is listed as “on track” rather than complete or delayed. The reviewer is not sure whether this may be a typo and perhaps should have been listed as June 30, 2023. The reviewer appreciates that the team has also been responsive to reviewer feedback, and during Fiscal Year 2023 the project team has been working to assess the extensibility of the machine learning (ML) framework to new joining and manufacturing processes. That work should be valuable.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

This reviewer praised the collaboration between PNNL, ORNL, and GM as excellent and said that the strong connections between the partners are contributing to the successes of this project. The team is doing a great job of fully leveraging a valuable dataset provided by GM.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer found the future work is well planned and purposeful. One planned activity of note calls for the development of resistance spot welding process designs based on predictive ML modeling, which will be transferred to the industry partner. This will be valuable to GM and will also demonstrate the commercial relevance of this framework for improved multi-material joining.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer confirmed that the project is well aligned with DOE objectives in multi-material joining.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer found that the resources are sufficient.

Presentation Number: MAT229
Presentation Title: Development of a Novel Magnesium Alloy for Thixomolding of Automotive Components
Principal Investigator: Govindarajan Muralidharan (Oak Ridge National Laboratory/Fiat Chrysler Automobiles LLC)

Presenter

Govindarajan Muralidharan, Oak Ridge National Laboratory/Fiat Chrysler Automobiles LLC

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

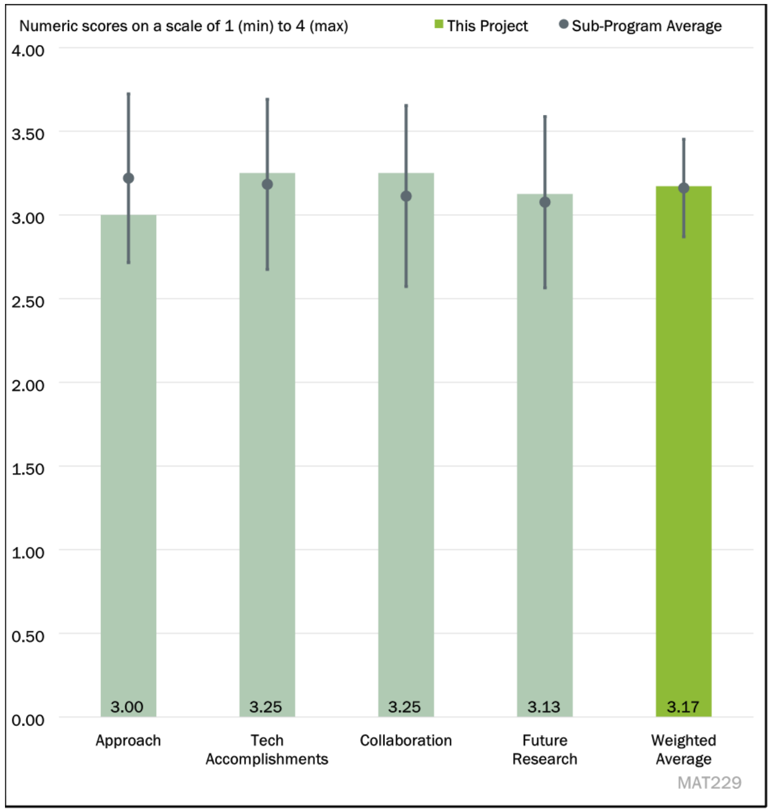

Figure 5-11 - Presentation Number: MAT229 Presentation Title: Development of a Novel Magnesium Alloy for Thixomolding of Automotive Components Principal Investigator: Govindarajan Muralidharan (Oak Ridge National Laboratory/Fiat Chrysler Automobiles LLC)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer praised the approach taken by the principal investigators as thorough and systematic.

Reviewer 2:

This reviewer pointed out that this a LightMat project in which a national laboratory collaborates with an industry partner to address a technology issue. In this project, ORNL worked with Fiat Chrysler Automobiles (FCA), Leggera Technologies, and Magnesium USA, to develop a methodology for easy thixomolding processing of Mg alloys. Using the low-cost thixomolding approach, Mg alloys, which are generally quite brittle, can be shaped. The goal of the project is to develop design and processing of new alloys with improved ductility over the baseline and eventually demonstrate it by fabricating a vehicle component. A successful development from this project could help with introducing Mg alloys as light weighting materials in vehicles.

Reviewer 3:

This reviewer notes that the barriers to Mg castings are the melting point and material properties. The team down-selected two alloys with similar melting points of AZ91D with higher ductility and yield strength. The project has progressed to die casting a spare wheel carrier, but the reviewer noticed that the milestones have a gap of over a year that doesn't show progress on the project. Only Mar. 2022, June 2023, and Sept. 2023 is on track for a component level materials evaluation from the cast component.

Reviewer 4:

This reviewer did not believe it was clear why a new alloy for thixomolding is needed. An existing, more ductile alloy such as AM20 or AM50 in die casting conditions should meet the required high elongation (15%-18%), in the reviewer's assessment.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

According to this reviewer, the project yielded new alloy compositions that can be thixomolded and demonstrated improved ductility and strength. Further, using this process, a vehicle component was manufactured. The project progress was, for the most part, in accordance with the plan. However, the corrosion test results were not available, and testing is being conducted and is expected to be completed by end of the fiscal year.

Reviewer 2:

The accomplishments of the team are commended by the reviewer. The team has been able to derive an alloy which has outperformed their reference alloy, AM60B. There are, however, some issues that remain to be resolved, including: (1) The elongation and other targets of Alloy #1 were met in the laboratory scale batch production. However, the elongation target was not met in the production run. The team took great pains during the presentation to explain why this occurred. The question is whether they would have the time and funds to demonstrate that they can rectify this issue by project's end in the way they explained it during the presentation; (2) A cost analyses to confirm that money was saved by their methodology and new alloy is missing. The analyses should include the cost of weight saving per unit. This figure should be compared with VTO's targets; (3) It is not immediately apparent in the bar charts presented (e.g., Slide 13 and Slide 14) whether the data presented were from single data points or from average values. An indication as to whether these are single values or averages, as well as the inclusion, or an indication, of error bars/error levels would be both prudent and helpful; (4) The reviewer is aware that not all of the latest results were presented at the meeting. The end of the project is about 3.5 months away. The reviewer questions whether the remaining tasks will be finished by the new deadline for completion of Sept. 2023.

Reviewer 3:

This reviewer believes that a successful process window was achieved for the component casting with Alloy #1, but Alloy #6 needs addition trials. Progress was made with Alloy #1 demonstrating the fine microstructure achieved that shows good strength and ductility. Alloy #1 shows increased strength and elongation over the standard AM60B, as indicated by the 25% finer grain size, which improves the property performance. The progress also showed the improved strain rate performance of the standard AM60B alloy.

Reviewer 4:

This reviewer found that Alloy #1 only achieved 10% elongation which is not better than die cast AM60B alloy.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

This reviewer lauded outstanding collaboration among the members. The reviewer did not find a clear breakdown of cost share among the team members but said that it appears that Leggera Technologies contributed the most.

Reviewer 2:

This reviewer found that the synergies amongst the collaborators are clearly laid out on Slide 18, which is a good response to concerns express in a previous review. The reviewer commended the team for this.

Reviewer 3:

This reviewer stated that there had been good collaboration among the three organizations on this project.

Reviewer 4:

This reviewer found it difficult to understand from the presentation who contributed what work. The slide indicates the breakdown of activities, but it would be easier to understand the workflow collaboration if the slides had the collaborators' symbols and any coordination activities between collaborators had been indicated.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer approved that the future plan includes corrosion testing on the commercially fabricated thixomolded parts. Additionally, mechanical testing on the commercial parts will be important.

Reviewer 2:

This reviewer references the reviewer's previous comments in Section 4 about the elongation of Alloy #1 in the production run, and about the cost analyses of the part to demonstrate not just weight savings, but the cost of the weight saving per unit mass.

Reviewer 3:

This reviewer found the future work to include a good list of items that includes corrosion, more high strain-rate for impact damage, and electrochemical work on Alloy #1. There appears to be no discussion of Alloy #6 for completion, raising the question to the reviewer of whether the team might not see a path forward for future work with that alloy.

Reviewer 4:

This reviewer hoped that the final casting trials and testing can provide better properties. Otherwise, no significant improvement has been achieved in this project (unfortunately).

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer confirmed that the work contributes directly to weight savings and improvement of fuel efficiency in vehicles.

Reviewer 2:

This reviewer found the project relevant to lightweighting.

Reviewer 3:

This reviewer assented that vehicle lightweighting by using Mg alloys that can be fabricated at somewhat lower temperatures could benefit the environment.

Reviewer 4:

This reviewer said that the project supports the VTO program via weight reduction and high-speed processing. The alloy development improves the performance with would allow for even further weight reduction with a redesigned component.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer said that the resources and the cost share are commensurate with the project tasks.

Reviewer 2:

This reviewer believes that the project is in line with resources for the progress that was made against the stated milestones and are on track for completion.

Reviewer 3:

According to this reviewer, it is difficult to assess whether the team has sufficient funds to complete the work. Vital information to make that assessment is missing.

Presentation Number: MAT231
Presentation Title: Light Metals Core Program Introduction
Principal Investigator: Glenn Grant (Pacific Northwest National Laboratory)

Presenter

Glenn Grant, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 50% of reviewers felt that the resources were sufficient, 50% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

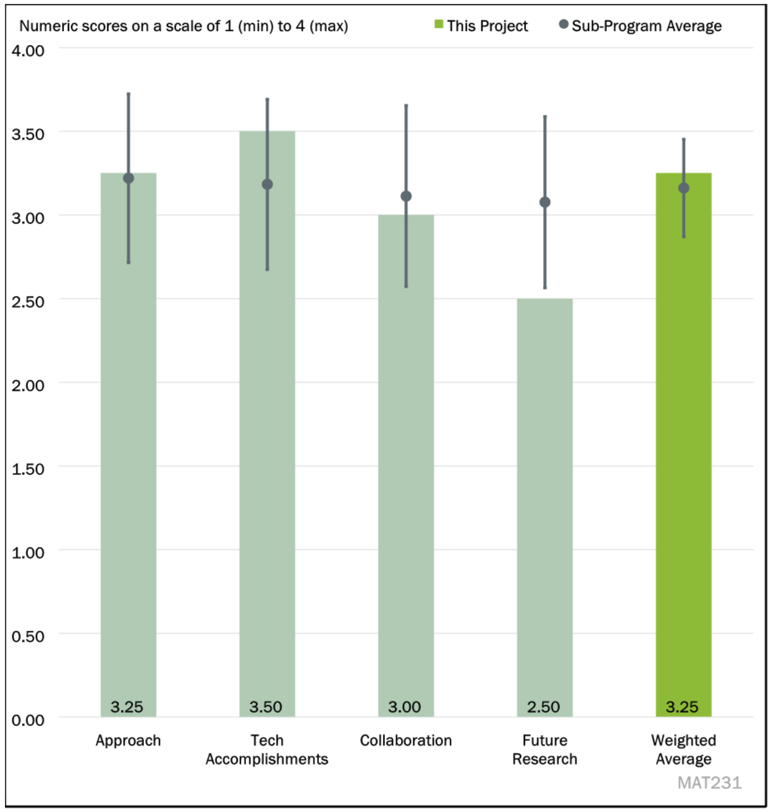

Figure 5-12 - Presentation Number: MAT231 Presentation Title: Light Metals Core Program Introduction Principal Investigator: Glenn Grant (Pacific Northwest National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer found that the program focuses on critical technical issues associated with light metals.

Reviewer 2:

This reviewer believes that this project is the flagship program for the laboratories to work with industry focusing on light metals; the projects are well thought out and contribution from industry is significant. Wrought and cast light metals (Al and Mg) are studied with focus on property improvements. The data from the projects are being used to develop predictive models, which the reviewer considers a good idea. The selective strengthening may be a good idea but models in predicting the performance may be delayed. The reviewer suggested that the project needs more discussion with end users to facilitate the uptake of these ideas.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer finds that most of the projects show good progress. But some projects (such as simulation projects) are still at early stage of development. The reviewer sees a need to work closely with automotive OEMs to implement some of the technologies.

Reviewer 2:

The reviewer says that the project team has had significant interaction with industry partners and many publications have been issued. However, more efforts are needed in modeling and in predicting the performance of local property variations.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

This reviewer pointed out that OEM and Tier 1 suppliers are involved and that the projects are interactive with useful in-kind contributions from industry in the form of materials/products.

Reviewer 2:

This reviewer found the collaboration to be generally good, but not always have the best teams been used to address specific technical issues. Although the program is to support national laboratories, the reviewer suggests that top experts in universities should be invited as consultants to some of the projects to fill expertise gaps in some cases.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer said only that the program is coming to an end by the end of Fiscal Year 2023.

Reviewer 2:

This reviewer found not much future work presented and suggests running more focused efforts in the future and building the best teams beyond just the two national laboratories.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer found the work to be highly relevant to vehicle lightweighting.

Reviewer 2:

This reviewer predicted that light metals will be used in more quantity in vehicles to achieve light weighting, energy efficiency, and cost reduction and pointed out that this research is focused on modifying, enhancing local properties to enable better performance.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer believes that the program is well funded but suggests that in future the projects can be planned with go/no-go points to close ones with less benefits and start new ones.

Reviewer 2:

This reviewer believes that more resources are needed to overcome key challenges in sustainability and modeling development.

Presentation Number: MAT235
Presentation Title: Light Metals Core Program - Thrust 4 - Residual Stress Effects
Principal Investigator: Ayoub Soulami, (Pacific Northwest National Laboratory)

Presenter

Ayoub Soulami, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

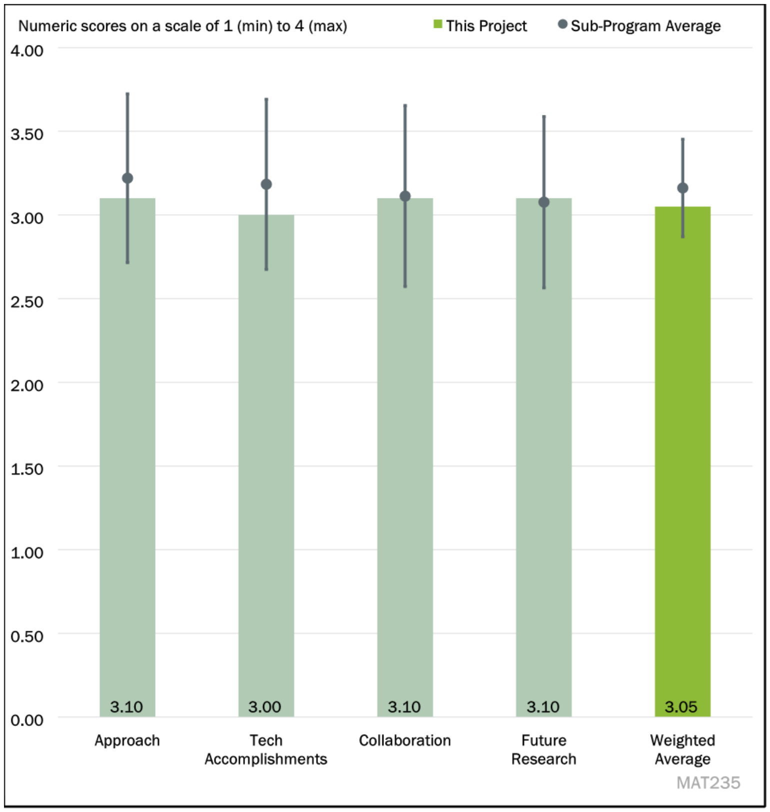

Figure 5-13 - Presentation Number: MAT235 Presentation Title: Light Metals Core Program - Thrust 4 - Residual Stress Effects Principal Investigator: Ayoub Soulami (Pacific Northwest National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer finds the project to be a good one that is focus on residual stress measurement and modeling in the Lightweight Metals Core Program (LMCP).

Reviewer 2:

This reviewer pointed out that the technical target of this project focuses on developing an integrated suite of computational models to accelerate product development cycle time by understanding the residual stress distribution as a function of process conditions and maintain part dimensional stability. In this review period, the project developed two different modeling tools for simulation purpose such as residual stress only or residual stress along with distortion predictions for friction stir processing and bending processes demonstrated on Al and Mg materials. The reviewer notes that the team is currently in progress for Milestone 2.0 with a due date of Sept. 2022 and questions what caused the delay or whether it was a misprint and should be 2023 instead of 2022. If the team targets to improve the model by end of Sept. 2023, it is a reasonably planned timeline, according to the reviewer.

Reviewer 3:

This reviewer believes that the project correctly identified the problem of distortion due to residual stresses.

Reviewer 4:

This reviewer notes that the project is very much focused on modeling and predictions with simulations. The experimental validation, however, seems to have commenced has not advanced sufficiently to address the model validation with respect to residual stresses aspect sufficiently.

Reviewer 5:

This reviewer feels that the project is well designed, and the timeline is reasonable.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer says that the accomplishments are generally effective.

Reviewer 2:

This reviewer praises the technical progress as excellent but. records a slight concern that the project is at the mercy of the overall program projects and focused solely on PNNL projects.

Reviewer 3:

This reviewer considers the developed modeling methods to have delivered good agreement in residual stress distribution outside of friction stir zone, which effectively assists the process path design for component strength and dimensional stability. However, the current simulation methods developed do not incorporate material property changes with precipitation evolution in the stir zone and, therefore, generate a discrepancy in predicted stress profiles within the stir zone. The reviewer would find it helpful if more details could be provided to explain how the model will be further improved to address this discrepancy.

Reviewer 4:

This reviewer confirmed that the project predicts residual stresses with some level of validation, but is concerned that it did not predict distortions, which are real challenges in industrial applications, according to the reviewer.

Reviewer 5:

This reviewer believes that the model development in this project is very good but that. residual stress measurements still need more work. The methodology was shown as an appendix but not explained in the presentation so that the effort could be evaluated. The source of residual stresses was expressed as being related to differences in the microstructures but there is not much analysis of these microstructures, according to the reviewer.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

This reviewer believes that the laboratories have good division of effort and seem to be collaborating substantially.

Reviewer 2:

This reviewer considers that collaboration is well coordinated with the partners.

Reviewer 3:

This reviewer found good coordination with PNNL activities but believes that it would be good to coordinate with the ORNL activities as well.

Reviewer 4:

According to this reviewer, it would be helpful to clarify what tools will be used to measure the micro and macro residual stresses at PNNL and ORNL, respectively, and how efforts on modeling of residual stress at the two sites will be coordinated. It is unclear to this reviewer what the role of ANL is in future research.

Reviewer 5:

This reviewer suggests working closely with the computer aided engineering (CAE) community in the automotive industry to predict distortion in real parts.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer found there is good focus on residual stress measurements in future work planned and looks forward to seeing these results at the end of the project.

Reviewer 2:

This reviewer said that the proposed future research is adequate.

Reviewer 3:

This reviewer said that the proposed future research is reasonable to overcome barriers.

Reviewer 4:

According to this reviewer, it is unclear how model prediction accuracy can be further improved within the stir zone, especially for Al alloys with precipitation evolution. The reviewer is concerned regarding a lack of details on whether a comprehensive material property database will be established to address this technical barrier.

Reviewer 5:

This reviewer suggests implementing the residual stress and distortion models in commercial software used by industry to have real impact.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer noted that the project supports LMCP which directly addresses the glider weight reduction mission pertaining to lightweighting.

Reviewer 2:

This reviewer pointed out that the project aims to predict part performance made of Al or Mg alloys with localized microstructures, residual stress and distortion introduced by friction stir and bending processes and assist to optimize process parameters for residual stress and distortion control. However, it is unclear to the reviewer how the models developed currently would be able to assist in developing stress relief procedure since it requires a creep database, especially for Al alloys with precipitation mechanisms.

Reviewer 3:

This reviewer finds the project to be relevant to lightweighting.

Reviewer 4:

This reviewer holds that the residual stress prediction is important in vehicle construction; the models will be very much material specific, and it would be good if models can be made more generic.

Reviewer 5:

This reviewer believes that the project supports overall the VTO materials subprogram.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer affirmed that the resources are sufficient.

Reviewer 2:

This reviewer said that the resources seem sufficient.

Reviewer 3:

According to this reviewer, sufficient resources are being applied to deliver milestones.

Reviewer 4:

This reviewer noted that $250,000 seem to be remaining for residual stress measurements. It was not clear to the reviewer, however, how these funds were to be used but the reviewer considered them to be sufficient.

Reviewer 5:

This reviewer pointed out that the team consists of three national laboratories with advanced measurement and simulation tools. The reviewer, however, suggested that it would be more helpful if the team can clarify what are the exact tools to be used at each partnering site.

Presentation Number: MAT236
Presentation Title: Advanced Characterization and Computational Methods
Principal Investigator: Thomas Watkins (Oak Ridge National Laboratory)

Presenter

Thomas Watkins, Oak Ridge National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

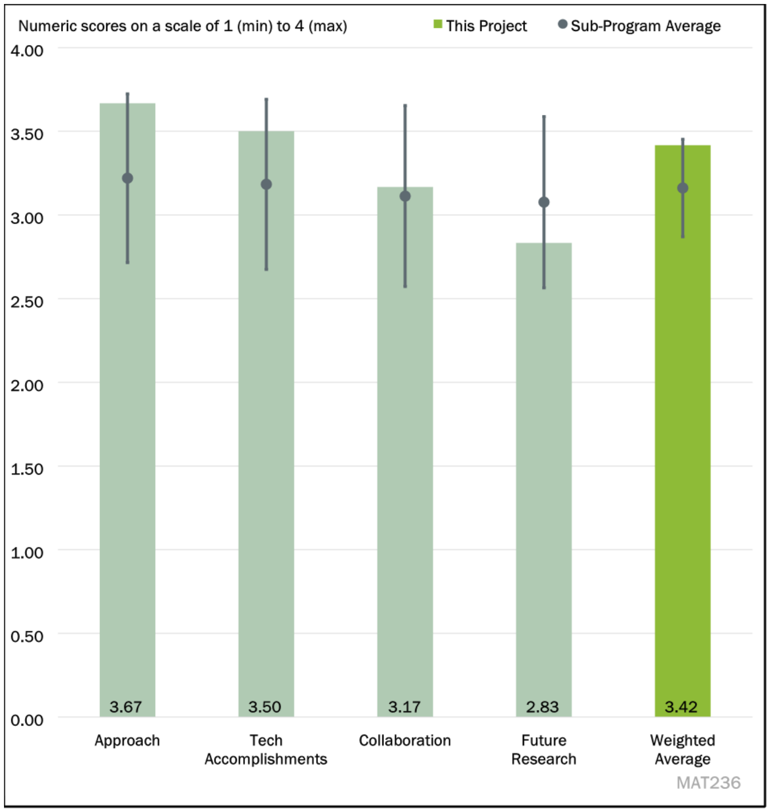

Figure 5-14 - Presentation Number: MAT236 Presentation Title: Advanced Characterization and Computational Methods Principal Investigator: Thomas Watkins (Oak Ridge National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer opined that new propulsion materials are needed to address current technology gaps for electric powertrains in light-duty and heavy-duty vehicles. The team of national laboratories is applying advanced materials characterization and computational tools to accelerate the development of the next generation of powertrain materials with superior combinations of properties, manufacturability, and cost to enable the design of future advanced electric vehicles. This database of material properties is permitting the accelerated development of materials needed to support the improvements needed to successfully deploy EVs. The process to select these projects includes a review of the proposed project by the laboratory leaders, then either rejection, suggested revisions, or acceptance. This appears to the reviewer to be a fair way to get tasks integrated into the project, as these laboratory leaders are the most knowledgeable about the status of the database and where new capabilities are needed.

Reviewer 2:

The word “accelerate” is emphasized heavily in the Thrust 4 goals, but the actual level of acceleration is unclear (unlike, for instance, the Materials Genome goals of “2x faster,” etc.…). A more thorough understanding of materials behavior/responses is most certainly being elicited, and overall, the work of the groups within this area is commendable.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer noted that multiple activities are being performed under this project. These efforts are expanding the database of material characteristics needed to support the development of more efficient electric propulsion systems. Tasks underway include: (1) ultra-conductor development for enhanced EV performance (2) Al-Ni alloys for improved electrical properties (3) Al-Ni alloys microstructure evolution on electrical and thermal conductivities, (4) electrical and magnetic properties characterization, (5) thermal properties in lightweight alloys for EV propulsion, and (6) carbon nanotube coating as a thermal interface material. Most work is being performed to understand and improve the electrical and thermal properties of materials. The materials with the most promise appear to be Al-Ni alloys and carbon nano-tube coatings. The national laboratories leveraged their impressive capabilities to perform the testing needed to understand these materials. Success is difficult to assess for these types of projects; however, the impact factor assessment appears to be a good way to assess. Sixty-six percent (8 of 15) of the journal publications and 63% (5 of 8) of the articles with significant Thrust 4 (Advanced Characterization and Computation) were assessed as having an Impact Factor of 5.

Reviewer 2:

This reviewer would like to see the capabilities of the teams extended a bit more than what was summarized. According to the reviewer, the effect of cooling rate on the refinement of a microstructure is certainly interesting but hardly cutting edge within the current research.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

This reviewer found that the three national laboratories participating as program partners, ORNL (Program Lead), PNNL, and ANL, are working together and effectively using their unique tools to support the development of next generation EV powertrain materials. The National Renewable Energy Laboratory (NREL) is also involved by offering access to the High Performance Computer User Facilities. This arrangement appears to be an effective way to perform the work using facilities that are best suited to complete the proposed subtask activities.

Reviewer 2:

This reviewer noted that the work is being spread across three national laboratories that are extensively familiar with one another based on collaboration across a vast number of programs.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer pointed out that the researchers will continue to expand on the research to improve electrical and magnetic measurements for EV materials. In the eyes of the reviewer, these are critically important material properties for electric vehicles. Additional work is planned on developing/understanding ultra conductors using the ShAPE process. Researchers will continue to implement the eutectic growth cellular automata model in open foam for high performance computing. All three activities are needed to cost-effectively help improve the materials being used in EVs.

Reviewer 2:

According to this reviewer, future research for the five-year program seems to be "continuing doing what we are doing." While the reviewer finds this appropriate, the reviewer notes that long term programs can ideally leverage discoveries to branch in new directions, even within the stated focus area.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer states that the project is directly relevant to the VTO Materials subprogram objectives.

Reviewer 2:

This reviewer confirms that the areas being addressed meet the VTO objectives.

Reviewer 3:

This reviewer finds the project is aligned with the Materials subprogram.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer believes that these subprojects complement the activities being performed outside of this project. This appears to the reviewer to be a cost-effective approach to keep the ICME database and modeling tools updated and accurate.

Reviewer 2:

According to this reviewer, a considerable amount of funding is being provided, but the impressive publications list provides strong evidence that this is project money well spent.

Reviewer 3:

This reviewer finds that the resources are sufficient.

Presentation Number: MAT237
Presentation Title: Materials, Lubricants, and Cooling for Heavy Duty Electric Vehicles
Principal Investigator: Jun Qu (Oak Ridge National Laboratory)

Presenter

Jun Qu, Oak Ridge National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 25% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

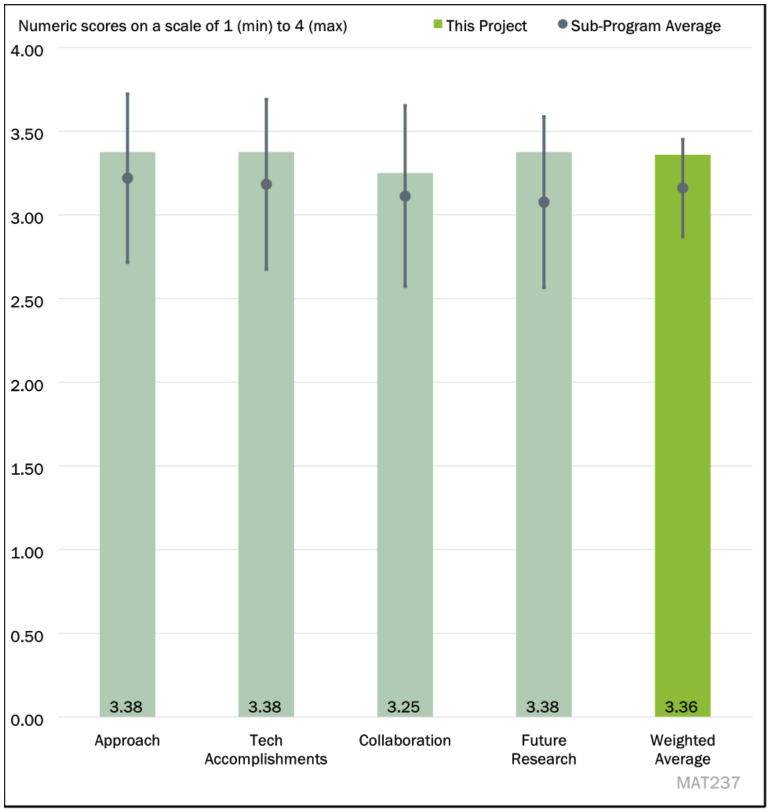

Figure 5-15 - Presentation Number: MAT237 Presentation Title: Materials, Lubricants, and Cooling for Heavy Duty Electric Vehicles Principal Investigator: Jun Qu (Oak Ridge National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer characterizes the project as leveraging CNTs due to their exceptional thermal conductivity and self-lubricating capabilities and adding them to EV fluids for improved heat transfer and lubricating efficiency. The project is using chemical vapor deposition to create a CNT coating for EV thermal and friction management.

Reviewer 2:

This reviewer finds the project to be very exciting research that is approaching real world applications. The team has a well-developed research plan to successfully demonstrate both super-lubricity and heat transfer efficiency. By integrating CNTs, this work provides a pathway for both characteristics. Through the research, a process to organically modify the CNTs has been established and a pathway established for using polar CNTs and non-polar CNTs in lubricating oil with little impact on viscosity. CNTs were assessed as an approach to improve thermal impedance reduction through the use of a CNT coating on a part of a thermal interface material. Leveraging the existing knowledge from the ICME database was a cost-effective approach to address issues encountered with EVs in regard to cooling and parasitic friction challenges.

Reviewer 3:

This reviewer calls the project an interesting approach to re-visiting the extraordinary properties of CNTs.

Reviewer 4:

This reviewer said that the primary challenge of how to use CNTs as an additive or a coating was described and addressed.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer identified as notable accomplishments in the least year: success in CNT's oil suspension and organic modifications to mitigate the oil viscosity rise due to addition of CNTs. Minimal addition of modified CNT's (0.1%) increases oil's thermal conductivity by 10-12% and volumetric heat capacity by 10-16%. CNT coatings were formed with low-cost chemical vapor deposition process and provide super lubricity which demonstrated 40-60% reduced thermal impedance.

Reviewer 2:

This reviewer recounted how a chemical vapor deposition process was used to form a CNT coating growth on stainless steel and Al alloy. This coating provided super lubricity in a macro-scale for over 500,000 cycles in a laboratory test. This also provides an emergency coating to ensure that, if lube oil is lost, low friction operation can continue for an extended period of time. The CNT coating could also provide 40%–60% reduction in thermal impedance, when combined in an interface in a non-friction environment.

Reviewer 3:

This reviewer said that progress seems good with the inclusion of considerable work in the friction reduction category. Some baselining of the characteristics would have been helpful to the reviewer. The reviewer poses a question of how the wear compares to a diamond like carbon coating and to a hard coating or surface treatment with standard lubrication.

Reviewer 4:

This reviewer notes that the focus, thus far, has largely been in developing a method to suspend CNTs or to coat other materials with CNTs. While good progress has been made in these efforts, it still seems to the reviewer that the practical challenge of use of CNTs has yet to be addressed.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

This reviewer observed that there is a CRADA with Valvoline regarding existing lubricants and a CRADA with Rocky Mountain Research Institute regarding coatings is in the process.

Reviewer 2:

According to the reviewer, the alignment of the project team with a national laboratory lead, ORNL, enables it to leverage its unique capabilities from other related projects under Thrust 4 to maximize the investment made by DOE. ORNL is also setting in place the mechanisms needed to commercialize this technology as it develops CRADAs with industry partners. These arrangements are critical to bringing this technology to the commercial marketplace. Typically, university participation is requested to be included as part of these projects. However, the reviewer is of the opinion that, since this project is much closer to commercialization, university participation would not provide significant value as CRADAs have been/are being executed with industry participants.

Reviewer 3:

This reviewer thinks that Valvoline is certainly an ideal partner.

Reviewer 4:

This reviewer said that, although the presentation addressed who was collaborating, how they were working together and what roles each group was taking on was not as well addressed.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer believes that material characterization and systematic thermophysical and tribological evaluations are appropriate future research activities based on the project end date at the end of Fiscal Year 2023.

Reviewer 2:

In the estimation of this reviewer, several steps are still needed to develop a commercial product with this technology. On the lubricant side, work still needs to be done on stable CNT oil suspensions at elevated temperatures, optimization of size and concentration of CNTs in oil, impacts on electrical, thermophysical and tribological properties of the oil, and determination of what is required to meet EV fluid requirements. On the coatings work, work needs to continue with higher contact pressures and temperatures, assessments of impact of CNT size and number, determination of system thermophysical and tribological impacts, and development of commercial EV components using this technology.

Reviewer 3:

This reviewer offered that good follow-on work was identified. Despite the positive results being shown, there is a lot of work to do in this area before the adoption of CNTs.

Reviewer 4:

Though noting that it is likely outside of the current timeline, the reviewer suggests that doing some prototype testing inside engines or engine components may be a good check. The reviewer has a suspicion that the CNTs may behave in unexpected ways that may not be the same as what is optimal in a laboratory setting. The reviewer also suggests looking into the cost/scalability questions with using CNTs.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer finds that the project contributes to VTO’s materials program goals to accelerate development of advanced materials for EVs. Specifically, the project focuses on propulsion materials and lubricants for heavy-duty EVs to improve cooling efficiency and reduce parasitic friction in electric motors and electric vehicle axle gearboxes.

Reviewer 2:

The reviewer confirms that the project is directly relevant to the VTO Materials subprogram objectives.

Reviewer 3:

This reviewer characterizes the project as a rather advanced approach on potential improvements to lubricants.

Reviewer 4:

This reviewer says that the project addresses frictional losses that are common to all vehicles.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer offers that just under $500,000 per year funding seems appropriate for the project scope and accomplishments.

Reviewer 2:

This reviewer believes that the project's innovative approach to lubrication and cooling has significant commercial applicability in the EV space and throughout industry. The use of CRADAs should be encouraged to allow industry to invest in this promising research. DOE should also identify other possible applications of this exciting and cutting-edge research.

Reviewer 3:

According to this reviewer, the completion level identified indicates that some fast-paced work will have to occur at the finish.

Reviewer 4:

This reviewer suggests more interaction with the heavy vehicle industry as end users. Perhaps the interaction would be more about getting the industrial perspective, but it also seems to the reviewer that it might help with earlier adoption of these discoveries. Additional resources may also assist in evaluating cost and scalability, according to the reviewer.

Presentation Number: MAT241
Presentation Title: Advanced Processing and Additive Manufacturing for EV Propulsion
Principal Investigator: Beth Armstrong (Oak Ridge National Laboratory)

Presenter

Beth Armstrong, Oak Ridge National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 80% of reviewers felt that the resources were sufficient, 20% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

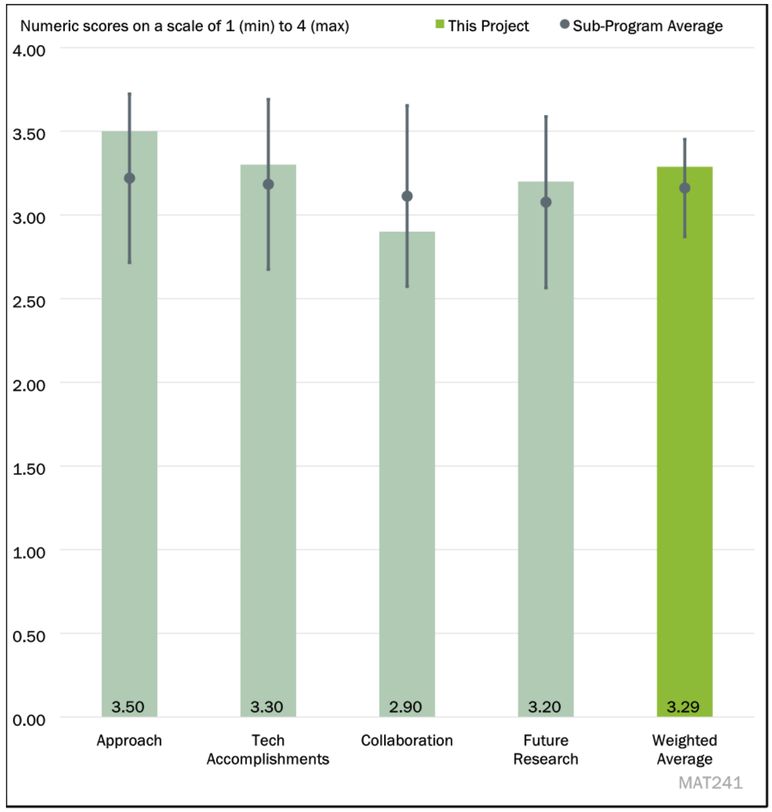

Figure 5-16 - Presentation Number: MAT241 Presentation Title: Advanced Processing and Additive Manufacturing for EV Propulsion Principal Investigator: Beth Armstrong (Oak Ridge National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer considers that the project's approach to developing tunable and lighter weight advanced ceramic materials and developing new processing methods for fabrication of wireless charging systems for EV applications is a good one, as not much information on this topic exists in the literature.

Reviewer 2:

This reviewer notes that this activity falls under Thrust 3 of the VTO PMCP, Advanced and Additive Manufacturing for EVs. New lightweight cost-effective ceramic materials are needed for wireless charging. Recycled ferritic powders currently dominate the resource supply chain and the impact of recycled powders is unknown. Since ferrites in use today were developed over fifty years ago, new characterizations and tailored compositions, the reviewer concludes that use novel architectures and processing techniques are needed. The ORNL team is developing tunable and lighter weight advanced ceramic materials. They are also developing new processing methods for fabrication of wireless charging systems for EV applications. They are completing this by using a 6-stage process: determine properties of interest; benchmark existing materials; develop new materials; optimize ferrite fabrication methods; and fabricate lightweight architectures using advanced processing techniques.

Reviewer 3:

This reviewer sees the work as approaching the topic of materials development from both the performance and manufacturing sides. This approach of optimizing the Ni dopant concentration for Curie temperature and permeability and also the dispersant concentration for stability in a slurry is useful for determining the candidate materials. The approach could be improved by adding a modeling component but with limited literature, which could be difficult. Overall, the project is well organized.

Reviewer 4:

This reviewer commends the project for making good use of computational thermodynamics approaches to supplement physical characterization. The ceramic vs metallic choice seems overly simplistic, according to the reviewer, who believes that ceramics often (or always) add a layer of complexity due to reduced yields from stochastic defects.

Reviewer 5:

This reviewer finds the research space here to be very broad and aspirational. As such, the reviewer finds it hard to determine which technical barriers are most relevant and how the planned approach addresses them.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer identified notable accomplishments in the least year to include baselining commercial materials, developing new materials by dopant chemistry, determining a need for a new processing method, and determining that the use of dispersants improves stability of ferrite powders.

Reviewer 2:

This reviewer found that the team has successfully completed a baselining of common commercial materials, making possible an assessment of composite and porous architectures. According to the reviewer, nonmagnetic cementitious space leads to the applicability of lighter weight porous structures. Dopant nickel ferrite ($NiFe_2O_4$) materials meet the Curie temperature requirements to permit induced magnetism. Sinterability is critical to control microstructure and strength of material. The reviewer believes that more fundamental understanding of Ni dopant materials is needed since large grains are needed for optimum magnetic behavior. A processing method to achieve larger grains is needed since sintered microstructure is highly dependent on the starting particle size. Sinterability and mechanical properties balance are critical. Researchers investigated the Zeta potential, finding that high Zeta indicated indicates a more dispersible powder. Slurry stability is needed to control the material architecture. Slurry stability improved with increasing Ni dopant concentration and increasing dispersant concentration. Doping creates complex spinel solid solutions and researchers have investigated the detailed defect chemistries of doped ferrites with computational thermodynamics.

Reviewer 3:

This reviewer believes that the project’s progress is good, including the identification not only of areas of progress, but areas where improvement is needed, which is a strong component of the direction of this research.

Reviewer 4:

This reviewer is concerned that the research, thus far, seems focused on a fairly-narrow composition range. It is not clear to the reviewer whether these are the best materials for the application or if additional alloy development would be beneficial.

Reviewer 5:

This reviewer saw good progress on identifying candidates. but finds it somewhat unclear how the last objective is going to be achieved in the time remaining.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

This reviewer found that the partners seem well equipped to perform analysis.

Reviewer 2:

This reviewer said that several ORNL facilities including the National Transportation Research Center and the Manufacturing Demonstration Facility are contributing to the project as is a commercial power vendor, Steward Advanced Materials.

Reviewer 3:

This reviewer commented that the project team led by ORNL is able to leverage its extensive in-house capabilities that are required to advance the material development work. Using the National Transportation Research Center and the Manufacturing Demonstration Facility, along with Raman microscopy and electron probe microanalysis, these facilities and tools provide the needed capabilities to assess the development of these materials. The addition of industry partner Steward Advanced Materials, (a commercial powder vendor), provides the team a new capability to assess actions needed to bring macro scale material production to the commercial marketplace. The reviewer believes that leveraging other national laboratory capabilities should be considered along with, when the time is right, the execution of a CRADA with an industry partner that would be interested in commercializing the material into a wireless charging solution.

Reviewer 4:

This reviewer noted that various reviewers have already pointed out the lack of partnerships outside of the laboratory, which is unfortunate because the work is applicable to extremely relevant current technology needs. The reviewer suggests that the team, perhaps take a closer look at startups or small companies that can join as in-kind contributors.

Reviewer 5:

According to this reviewer, the project seems to be mainly an in-house effort so far.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer stated that the future research is appropriate, considering that project completion in Fiscal Year 2023 includes continued optimization of processing techniques and modeling, as well as development of magnetic property testing techniques.

Reviewer 2:

This reviewer noted that ORNL is proposing to continue efforts to optimize colloidal processing techniques for casting and additive manufacturing fabrication. They also plans to continue modeling efforts to guide the development of future ferrite material compositions and to develop a model to guide design of novel architecture structures, which is to lead to the development of intermediate and large-scale magnetic property testing techniques. This approach appears to incorporate the right steps that are needed to develop a material for wireless charging systems.

Reviewer 3:

The reviewer commented that the proposed research into both processing techniques and modeling components is reflective of the level of understanding on the topic that the team has gained over the course of this program. The testing technique development presents a challenge.

Reviewer 4:

This reviewer pointed out that the principal investigator has identified a large margin for improvement of efficiency, even among benchmark materials. However, the reviewer suggests looking at slightly higher technology readiness levels (TRLs) with research directions such as scale models or similar tools so that environmental factors (water, concrete, salt, etc.) can be evaluated. Also, instead of the dynamic charging, charging while parked might be an easier near-term target that would also address some of the concerns about connectors in EVs, according to the reviewer.

Reviewer 5:

This reviewer lauds the project as certainly promising and a great jumping off point for future work and would like to see more specifics around each of the bullet points. For example, for the continued optimization of the colloidal processing techniques, the reviewer asks whether this research has indicated more promise in one technique over the other (extrusion vs. casting), whether the intermediate and large-scale testing techniques would be used (for production and/or for down selecting a large number of compositions, etc.).

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer confirms that the project supports the VTO materials subprogram objectives, as it is part of the PMCP’s advanced and additive manufacturing for EVs thrust and is developing new, lightweight and cost-effective ceramic materials for wireless charging.

Reviewer 2:

This reviewer said that the project is directly relevant to the VTO Materials subprogram objectives.

Reviewer 3:

This reviewer believes that there is no question on this program’s applicability to EV infrastructure development.

Reviewer 4:

This reviewer noted that the project links to materials and electrification challenges while expressing curiosity as to whether links to the batteries program have been explored since this style of charging would change the target cycle lifetimes and discharge rates.

Reviewer 5:

This reviewer held that wireless charging is an important advancement to improve adoption of electric vehicles and that better/cheaper solutions are needed.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer believes that the just under $300,000 per year funding seems appropriate for the scope and accomplishments of this project, which is ending in Fiscal Year 2023.

Reviewer 2:

This reviewer said that the resources appear to be sufficient to achieve the stated goals of the project.

Reviewer 3:

This reviewer questioned the project's being 75% complete with 3 months left.

Reviewer 4:

This reviewer found the resource question hard to gauge, as this seems to the reviewer to be a high risk/high reward project and commented that additional resources or collaborations for integration into road or other applications seem likely to be useful here.

Reviewer 5:

This reviewer noted that this project is very much a research project, so resources are fine.

Presentation Number: MAT242
Presentation Title: Advanced Processing and Additive Manufacturing for EV Propulsion, Advanced Ceramics and Processing for Wireless Charging Systems, Novel Ultra High Conductivity Composites for EVs
Principal Investigator: Tolga Aytug (Oak Ridge National Laboratory)

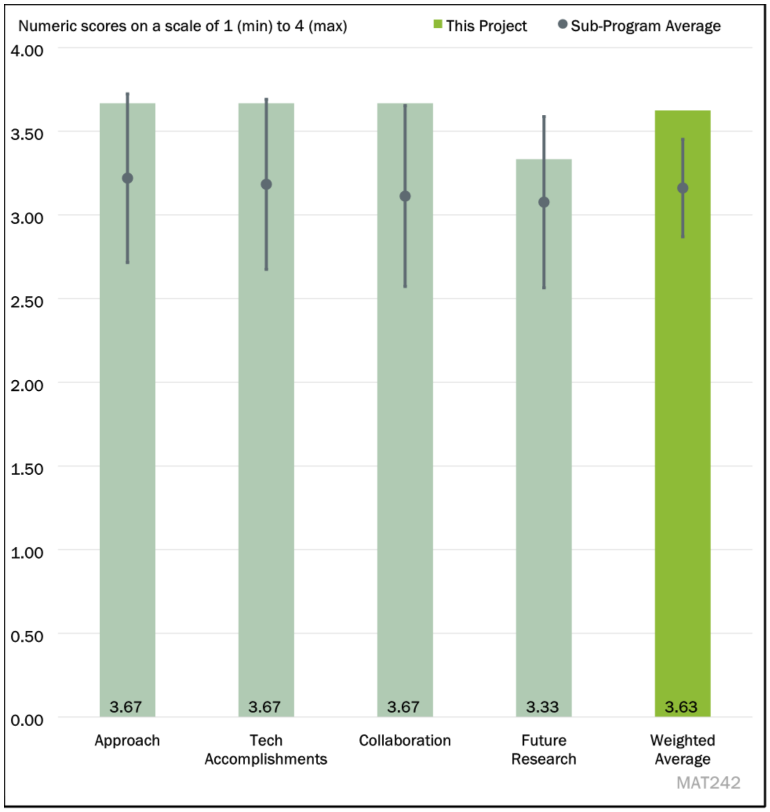

Figure 5-17 - Presentation Number: MAT242 Presentation Title: Advanced Processing and Additive Manufacturing for EV Propulsion, Advanced Ceramics and Processing for Wireless Charging Systems, Novel Ultra High Conductivity Composites for EVs Principal Investigator: Tolga Aytug (Oak Ridge National Laboratory)

Presenter

Toiga Aytug, Oak Ridge National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 67% of reviewers felt that the resources were sufficient, 33% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer pointed out that the project involves research on novel, ultra-high conductivity materials for EVs to enable the project aims to develop the materials to meet DOE 2025 power density and size performance targets and reliability goals. Reductions in EV components' volume/weight and improvements in efficiency are currently limited by the copper windings used for electrical conductivity. Research is being performed to improve the efficiency and lower the weight of electrical conductivity materials as compared to copper windings.

Reviewer 2:

This reviewer commended the project as a good mix of characterization and process evaluation to determine if the copper-CNT material is feasible and scalable.

Reviewer 3:

This reviewer found the project to be a well-designed study that answers several questions and shows improvement in conductivity with the addition of graphene. The team appears to have a good start on scaling up the production, according to the reviewer.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer described how ultra-high conductive materials are needed since the market for copper is growing significantly. A target for improved conductivity over copper has been set at 10%. Ultra conductive copper (UCC) with CNTs embedded in a copper matrix material is being explored. The project work has transitioned to demonstrating a double layer matrix from a single layer which provides validation that more layers can be added. Excellent interfacial adhesion was achieved between the copper and CNT layers. Copper has successfully infiltrated the CNT layer, which is very important for improved conductivity. Improved resistivity (from single layer at 4.5%–8.0% increasing with a double layer to 8.6%–11.2%) and increased ampacity (from single layer at 7.2%–8.4% to double layer at 14.0%–15.0%) have been demonstrated with the double CNT layer material. It was found that improvements in resistivity do not scale linearly with additional layers. These results were validated by a third-party test performed by Southwire, which performed ASTM resistivity tests for both volume and weight. Modeling through advanced computations indicates that increased electrical conductivity is predicted when a combination of nitrogen and electronic doping is used to increase the charge carrier density of the CNTs by an order of magnitude. CNTs are also shown to improve the mechanical strength (tensile and modulus) of the UCC matrix. However, the material does become less ductile than pure copper. A scaled-up production of the UCC copper matrix with copper sputter system that was modified for reel-to-reel operation was also modeled.

Reviewer 2:

This reviewer noted that the team built several prototype Cu-CNT composites and evaluated the electrical and mechanical responses, which showed improvement over the benchmark material. The team also fabricated material in a form more relevant for industrial use.

Reviewer 3:

This reviewer stated approvingly that the project has progressed well. The team demonstrated an incremental improvement on the parameters that they were assessing and verified the conductivity through third party testing. The progress appears to be on track to complete the project with fabrication equipment that can support the next steps.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

This reviewer commented that the alignment of the project team with a national laboratory lead, ORNL, enables it to leverage its unique capabilities from other related projects under Thrust 4 to maximize the investment made by DOE. ORNL is using the Oak Ridge Leadership Computing Facility, specifically the Compute and Data Environment for Science data analytics research facility, and the Summit supercomputer. ORNL is also preparing to move this project from laboratory research to commercial production. ORNL has partners with leading organizations, including Southwire, Chasm Advanced Materials, and General Graphene. With GM now showing interest in this project, a formal arrangement with the partners and GM in the form of a CRADA should be considered.

Reviewer 2:

This reviewer found the list of collaborators and how they are integrated into the project to be good.

Reviewer 3:

This reviewer believes that the team has coordinated well and is glad to see industrial involvement.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer stated that ORNL is proposing to continue efforts to optimize parameter space to establish the highest possible performance. Activities to assemble and evaluate the influence of multilayer UCC composites with additional copper/CNT stacks are also proposed. A scale up to an all-continuous reel-to-reel process and establishing key processing parameters for long- length (more than 50 cm) CNT deposition are also proposed. The team also wants to explore H_2O based CNT dispersion formulations combined with scalable CNT coating approaches. In addition to these activities, a comparison between recycled copper versus virgin copper should be completed to determine whether there are any differences in UCC performance.

Reviewer 2:

This reviewer did not see any finite element analysis or similar optimization approaches discussed by the principal investigator. It seems to the reviewer that determining the optimal mix of layer thickness and distance between layers could be investigated computationally, as could failure mechanisms.

Reviewer 3:

This reviewer thinks that the proposed future work is definitely on the right track in focusing on further scaling. The only thing the reviewer would add is that there needs to be an assessment of robustness and repeatability. This is especially important as more layers are added. This may also be incorporated into what the team is proposing, according to the reviewer, but the reviewer thinks that this does need to be addressed (even if only a preliminary study were to be done).

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer finds that the project is directly relevant to the VTO Materials subprogram objectives.

Reviewer 2:

This reviewer says that the project fits into the electrification and materials objectives.

Reviewer 3:

This reviewer affirms that the project is very timely and relevant.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer found that the team appears to have sufficient resources to complete the project by September 2023.

Reviewer 2:

This reviewer considers the resources to be sufficient to achieve the stated goals of the project. However, additional resources could accelerate UCC material to the commercial market. This should be considered, as copper demand is significantly increasing, and alternative ultra-conducting material is needed.

Reviewer 3:

This reviewer remarked that the team noted being overloaded.

Presentation Number: MAT243
Presentation Title: Manufacturing Demonstration of a Large-scale
Principal Investigator: Srikanth Pilla (Clemson University)

Presenter

Srikanth Pilla, Clemson University

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

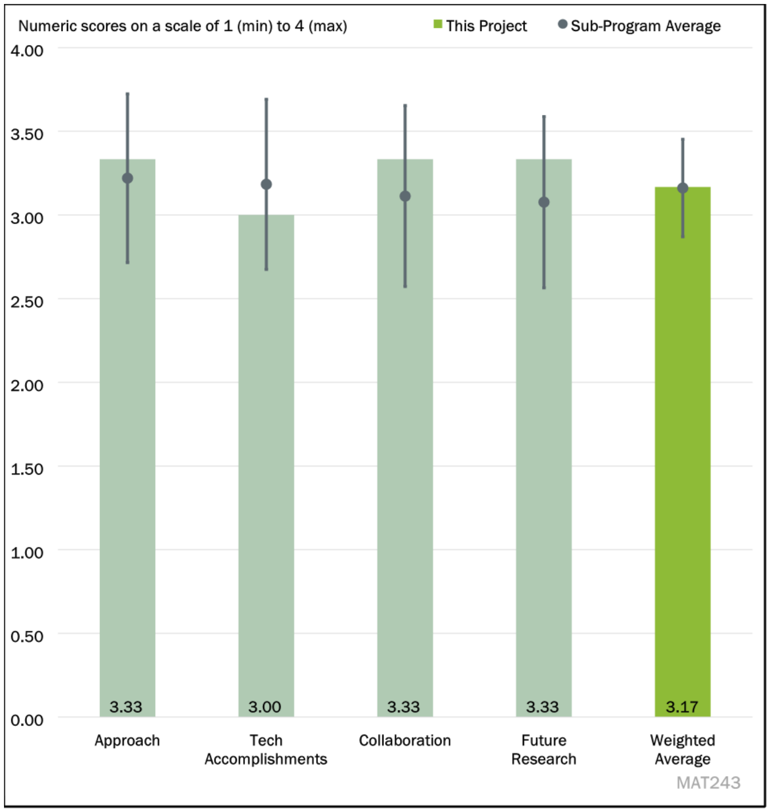

Figure 5-18 - Presentation Number: MAT243 Presentation Title: Manufacturing Demonstration of a Large-scale Principal Investigator: Srikanth Pilla (Clemson University)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer found that the team has focused on tasks including design and technology integration, multi-material joint modeling and experiments, cost assessment, cycle times and design optimization for full scale validation to sharply address the technical barriers identified.

Reviewer 2:

This reviewer considers the approach to be straightforward and reasonable.

Reviewer 3:

This reviewer pointed out that the overall approach of developing a new glider is essentially the same as any commercial OEM would take. However, the project team has identified opportunities for lightweight material integration into the body-in-white structure, which drives a number of new technologies. The project team has identified potential roadblocks and structured its project to address them. For example, development of a CF/metal joint is ongoing with process development and planned subsequent CAE card development. However, typically this requires validation of the material card on a drop tower hat section or the like which the reviewer does not see included in the work plan.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer determined that all tasks in Budget Period 1 were completed, and five tasks are in progress for Q3 2023–Q2 2024. In general, sufficient progress has been made for each planned target.

Reviewer 2:

This reviewer commented that, considering that the project is at a 30% completion level, the fact that the team has whittled down the selection to two concepts based on a set of criteria is appropriate. (The reviewer would have preferred for these criteria to have been identified and concepts weighted accordingly.) However, what is unclear to the reviewer is the method the team used to represent the various concepts under the loading conditions given that the CF/metal joint CAE card has not been developed at this point. Because representation of these CF/metal interfaces is the key to success for such an aggressive plan, this point requires greater elucidation within the project.

Reviewer 3:

This reviewer noted that, with the project being in its first year, it is rather difficult to evaluate the progress. The concept development appears to be good; however, it is rather attempting to be effective and qualitative, not quantitative. The numerically evaluated team's different concepts are based on a physics-based simulation; however, the fidelity of numerical simulations was not provided. Due to the limited presentation time, detailed explanations of the progress were not given.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

This reviewer considers the role of each partner in the project team to be clearly stated and good contributions are made from each partner from industry and universities. Involvement of nine companies from different aspects contributes significantly to the implement of the proposed work.

Reviewer 2:

This reviewer applauds the collaboration and coordination across the project team as being well-designed to create synergies.

Reviewer 3:

This reviewer commented that, although the project team includes a wide cast of members, this is not atypical for such a body-in-white development project. The weekly meetings and technical team discussions, which the reviewer assumes to be smaller, are very positive and, in fact, necessary, according to the reviewer. What is not clear to the reviewer is how and when the various specific deliverables (such as the CAE card for the CF/metal joint and determination of the feasibility of using recycled materials and the CAE card for such an optimized recycled content) are to be synced to the greater glider design project. A linear timing chart reminiscent of a typical week-by-week vehicle development plan highlighting the various data syncs, deliverables, etc., would help to show the greater picture of coordination across the project team.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer found that the future tasks are clear for addressing the remaining challenges and barriers, although it would be helpful to the reviewer to have been provided more details on the technical approaches to be used to achieve each task/objective.

Reviewer 2:

This reviewer praises the proposed future research as very focused and detailed, with an overall step-by-step approach. One thing which the reviewer believes may be helpful is identification of the critical path for development of this multi-material glider. This would facilitate identifying whether resources were allocated in the best manner to mitigate risk for the overall project.

Reviewer 3:

The proposed future work looks reasonable to this reviewer.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer confirmed that the project will support the Materials subprogram to achieve cost effective sustainable lightweighting vehicle body-in-white sub-systems through comprehensive evaluation of multi-material systems, joining methods, industry-standard manufacturing processes and recycling technologies.

Reviewer 2:

This reviewer holds that development of a multi-material joining technology as well as recycled fiber composites of lightweight materials addresses the technology development needs towards industrial applications. Its implementation would support mass savings and thus reduction of GHG emissions in addition to increasing the range for EVs by such mass savings.

Reviewer 3:

The redesign and manufacture of a high-volume mid-size sport utility vehicles' body-in-white sub-system to achieve cost-effective and sustainable lightweighting through component consolidation, state-of-the-art optimization tools, multi-material joining methods, industry-standard manufacturing processes, and recycling technologies while meeting or exceeding baseline performance is very relevant to VTO's mission space.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer found that the team collaborates with a very good list of industrial collaborators along with two universities to ensure achieving the stated milestones.

Reviewer 2:

This reviewer points out that this a large project with many participants. The project resources/budgets appear to be appropriate.

Reviewer 3:

This reviewer described how the project is a very complex integrated endeavor where there are critical technology development paths nestled within a conventional automotive glider development project. Unfortunately, there is no information regarding how the significant budget sum is allocated and broken down to address the critical technology roadblocks this project addresses, according to the reviewer. However, given that the key players (Honda, Ohio State University, Clemson) are all coming at this from their respective fields of experience, the reviewer feels that it is safe to assume an appropriate allocation of resources. This will be more evident after the second full year of completion.

Presentation Number: MAT244
Presentation Title: LMCP P1A - Sheet Materials with Local Property Variation
Principal Investigator: Scott Whalen (Pacific Northwest National Laboratory)

Presenter

Scott Whalen, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

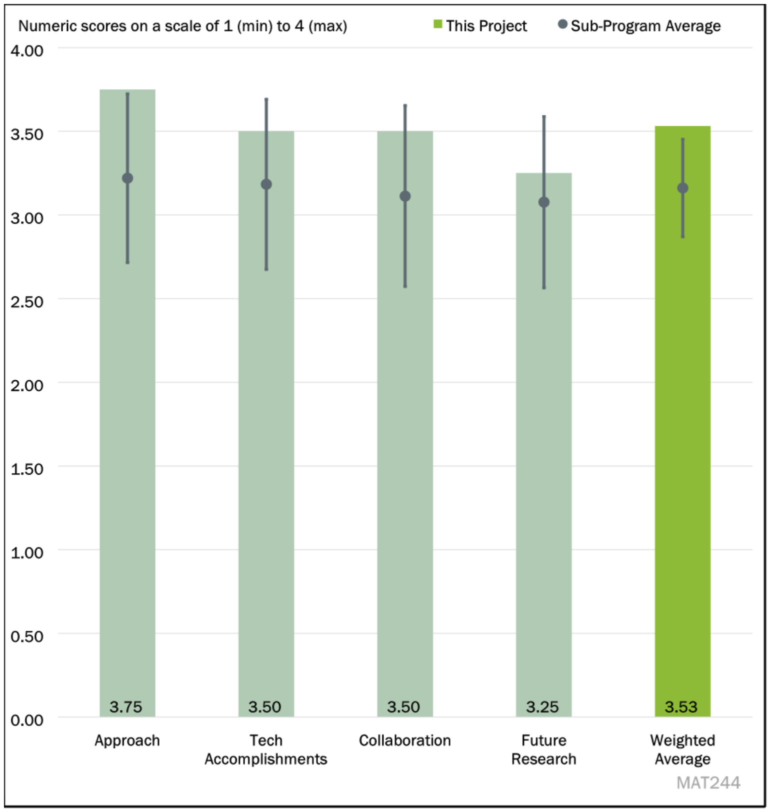

Figure 5-19 - Presentation Number: MAT244 Presentation Title: LMCP P1A - Sheet Materials with Local Property Variation Principal Investigator: Scott Whalen (Pacific Northwest National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer stated that enhancing local properties can be beneficial to certain applications.

Reviewer 2:

This reviewer notes that the approach has been changed from previous years, in which it involved converting the extruded pipe to sheet. This year the work was concentrated on extrusions with varying wall thickness as the end product. The approach is good, and the team had some earlier success in obtaining tubes with variable wall thickness. The team has also identified possible applications in collaboration with industry partners.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer stated that the process demonstrated significant property improvements in certain parts.

Reviewer 2:

This reviewer notes that the team has developed a process to obtain variable wall thickness in pipes and also developed a technique for rapid cooling. Progress has been made on measuring the performance. More efforts are needed to model and prediction of performance of variable wall thickness.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

This reviewer found good collaboration with industry.

Reviewer 2:

This reviewer said that the team has obtained advice from an OEM of the end use product that has raw material suppliers.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer determined that the future work proposed on process improvement and use of recycled material is good.

Reviewer 2:

This reviewer would encourage using post-consumer scrap to maximize impact.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer confirms that the project is relevant to vehicle lightweighting.

Reviewer 2:

This reviewer points out that the project is trying to develop technology to produce components with targeted properties at target locations. The success on the process development needs to be supported by design, models, and testing.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer states that the resources seem sufficient.

Reviewer 2:

This reviewer expects that there will be enough funds for experimental work but that maybe in future more efforts will be needed on design and modeling.

Presentation Number: MAT245
Presentation Title: LMCP P1B - Form-and-Print - AM for Localized Property Enhancement of High-strength Al sheet
Principal Investigator: Alex Plotkowski (Oak Ridge National Laboratory)

Presenter

Alex Plotkowski, Oak Ridge National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 67% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 33% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

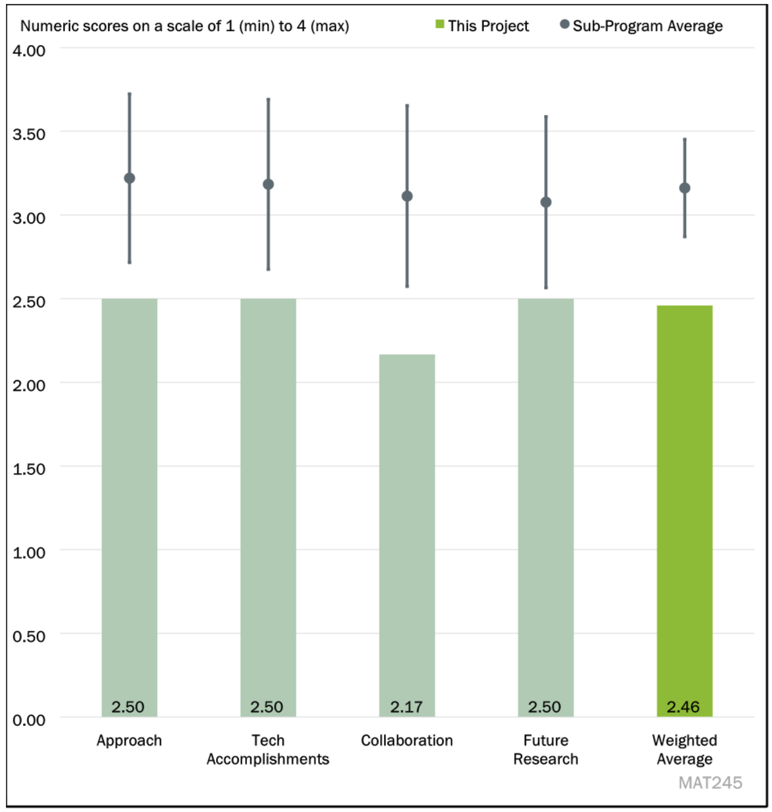

Figure 5-20 - Presentation Number: MAT245 Presentation Title: LMCP P1B - Form-and-Print - AM for Localized Property Enhancement of High-strength Al sheet Principal Investigator: Alex Plotkowski (Oak Ridge National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer commented that the approach is to modify or build surfaces on sheet material to change the local properties. While the added material can enhance the performance (strength, corrosion or fatigue) the change in structure of the underlying material can also influence the performance in a bad way. However, according to the reviewer, these properties cannot be determined without conducting some experiments and this project is conducting such experiments.

Reviewer 2:

To this reviewer, research on improving the ability to recycle alloys seems to be missing.

Reviewer 3:

This reviewer found that the approach identified adding a stiffening bead using wire additive and plug welding a predrilled hole. The problem for the reviewer is that the testing was done on a lap joint.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

It is somewhat concerning to this reviewer that Fiscal Year 2023 milestones are only half complete at end of the third quarter.

Reviewer 2:

This reviewer comments that the team has developed processes and evaluated multiple materials. While some improvements have been observed, the reviewer feels that the validity and usefulness of the process still needs to be proven.

Reviewer 3:

This reviewer described how 4047 filler wire used to plug weld a 6016 sheet through a pre-machined hole resulted in cracks at the interface and porosity in the infill. The increased stiffness achieved by adding beads to a flat sheet resulted in cracks, which is not acceptable. The results indicate that there is no benefit associated with using wire feed laser-assisted processing and no plan to address the situation. The feasibility of adding a stiffener to a 90-degree bend was not investigated, and not scheduled. The reviewer believes, but is uncertain, that the feasibility of plug welding using Al4047 wire through a machined hole in a 304 stainless steel to attach a 6061-Al bottom sheet is pending investigation in year 3.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

This reviewer believes that the team has good working relationships with partners. An OEM and suppliers are involved.

Reviewer 2:

This reviewer asserts that collaborations with Ford Motor Company, Mazak, Lincoln Electric and CompuTherm were noted but only collaboration with Mazak (procurement) was actually described.

Reviewer 3:

This reviewer sees no evidence associated with collaboration within the project team.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer is satisfied that end of the program is near, and progress is good with not much being planned before the end of the project in Fiscal Year 2023.

Reviewer 2:

This reviewer merely notes that proposed future research includes evaluating 4043 and 5356 wire to increase ductility and toughness of the beads.

Reviewer 3:

This reviewer refers to a listing of ideas having been provided with purposes defined and, in a few cases, given qualitative descriptions but considers it difficult to determine their likelihood of success.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer affirms that the project supports the VTO materials subprogram.

Reviewer 2:

This reviewer believes that the project supports the VTO subprogram objectives and is relevant to the materials joining program but feels that it has been poorly executed. The reviewer understands that the project objective is to investigate the feasibility of adding a stiffener rib to a formed sheet vertical wall or join dissimilar materials by plug welding through a predrilled hole using a TruLaser wire-fed 5-axis weld system. The project objective was not accomplished in the eyes of the reviewer.

Reviewer 3:

This reviewer affirms that improving the performance of sheet products can make them more viable for automotive applications.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer said that the number of milestones and the accomplishments appear appropriate for the level of funding.

Reviewer 2:

This reviewer believes that the project has been provided enough resources and the team has many different units of equipment available for the work.

Reviewer 3:

This reviewer asserted that the results presented do not appear to include any significant effort from the cross-functional team members.

Presentation Number: MAT246
Presentation Title: LMCP P1C - Local Thermomechanical Processing to Address Challenges to Implementing High Strength Al Sheet
Principal Investigator: Mert Efe (Pacific Northwest National Laboratory/Oak Ridge National Laboratory)

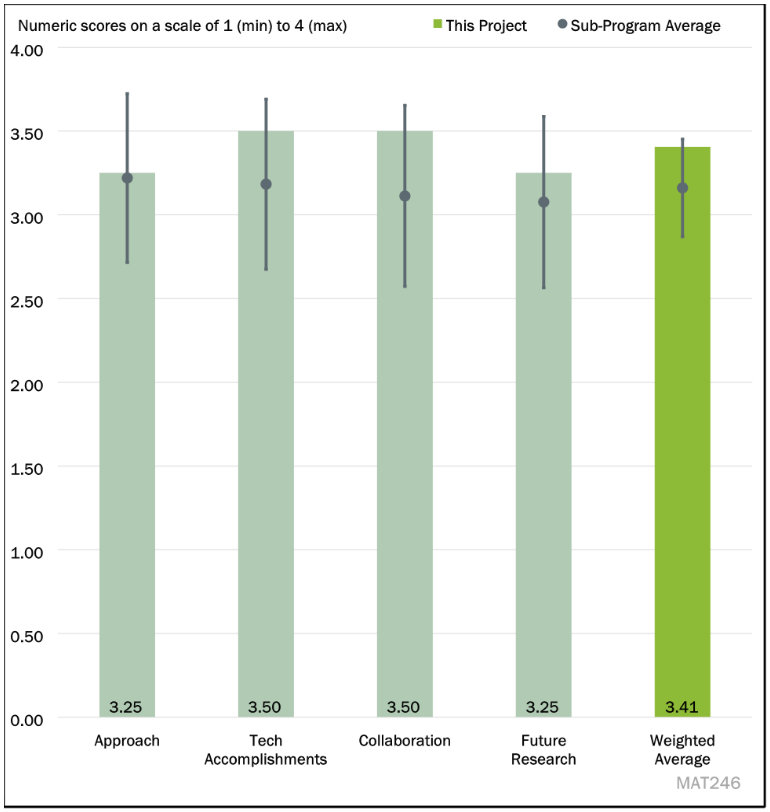

Figure 5-21 - Presentation Number: MAT246 Presentation Title: LMCP P1C - Local Thermomechanical Processing to Address Challenges to Implementing High Strength Al Sheet Principal Investigator: Mert Efe (Pacific Northwest National Laboratory/Oak Ridge National Laboratory)

Presenter

Mert Efe, Pacific Northwest National Laboratory/Oak Ridge National Laboratory

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer found that the project approach of evaluating four known unique thermo/mechanical processes that can be readily integrated into the manufacturing line to address local formability challenges with high strength heat treated Al alloys only in areas where improved formability is needed while maintaining high strength performance in areas where high formability is not needed is a novel approach that could provide some benefits when aimed at strength critical applications. However, at this point, it is not clear that any of the processes evaluated will be sufficiently cost effective to influence high volume production component applications.

Reviewer 2:

This reviewer complained that there was no discussion of the fact that making it more recyclable (T4 instead of T6) appears to reduce performance nor discussion of how to mitigate this.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The project seems to this reviewer to be on track: at end of the third quarter, ¾ of the milestones are complete.

Reviewer 2:

This reviewer commended that the project displayed good technical progress to date, achieving T4-level formability with some processes and close to T4-level with all processes evaluated. Laser processing formability improvements must still be evaluated, along with completion of modeling and characterization work, and work towards increasing process speeds. The project team should be able to complete these tasks in the time remaining.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

This reviewer lauded the team's robust collaboration with ORNL and said that evidence was provided of collaboration with industry, including Ford, GM, Honda, and Tier 1 suppliers.

Reviewer 2:

This reviewer approved of the level of collaboration and coordination between participants, noting that there seems to be very good cooperation between partners and the tasks of each being complementary to the others. Additionally, the desires of the automotive OEMs seem to have been incorporated in the project work.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer believes that the proposed future research is well suited to addressing the remaining project barriers. Laser processing formability improvements must still be evaluated, as well as completion of modeling and characterization work, and increasing process speeds. The project team should be able to complete these tasks in the time remaining.

Reviewer 2:

This reviewer pointed to a listing of ideas provided with purposes defined, and in some cases, given qualitative description, but without sufficient information, making it difficult to determine likelihood of success.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer affirmed that the project work supports the VTO materials subprogram.

Reviewer 2:

This reviewer pointed out that the project focuses on local formability improvements to allow for increased use of higher strength Al alloys with T6 and T76 heat treatments to enable weight reduction in strength critical applications where high strength Al materials might not normally be practical due to formability limitations.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer found that the number of milestones and the accomplishments appear appropriate for the level of funding.

Reviewer 2:

This reviewer stated that the sufficiency of resources has been demonstrated as the project is approximately 85% complete and the work accomplishments seem to closely mirror that.

Presentation Number: MAT247
Presentation Title: LMCP P2A - Solid Phase Processing of Aluminum Castings
Principal Investigator: Saumyadeep Jana (Pacific Northwest National Laboratory/Oak Ridge National Laboratory)

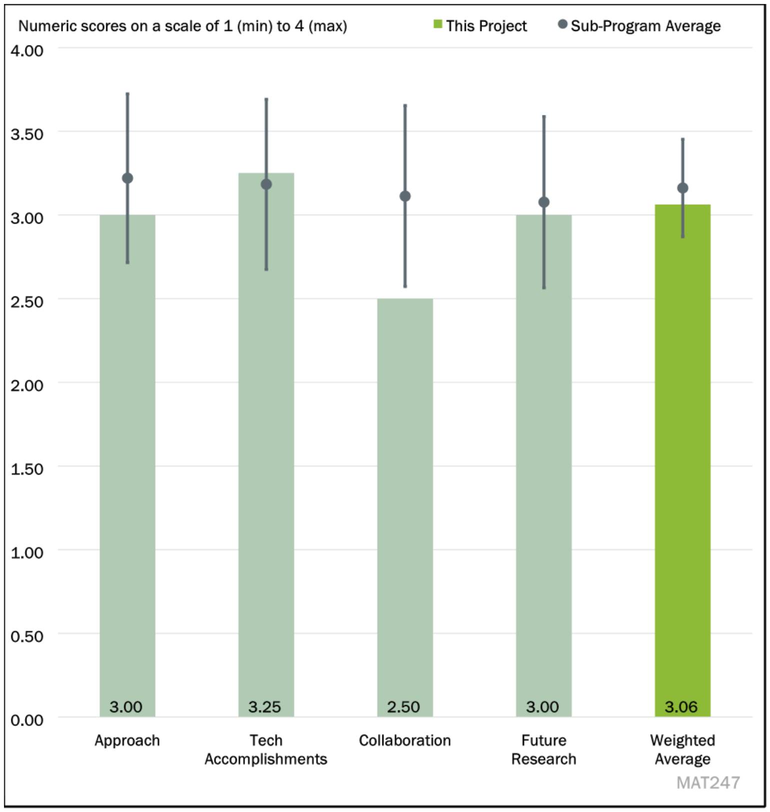

Figure 5-22 - Presentation Number: MAT247 Presentation Title: LMCP P2A - Solid Phase Processing of Aluminum Castings Principal Investigator: Saumyadeep Jana (Pacific Northwest National Laboratory/Oak Ridge National Laboratory)

Presenter

Saumyadeep Jana, Pacific Northwest National Laboratory/Oak Ridge National Laboratory

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

To this reviewer, the idea of modifying local structure to enhance properties of cast alloys is good. However, in die cast samples, the top surface is the best material and change may affect it adversely, suggesting that a non-intrusive technology would be useful.

Reviewer 2:

This reviewer finds the approach is appropriate in this project. The friction stir processing (FSP) particularly is making impressive progress.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer believes that friction sir welding as well as ultrasonic processing have improved fatigue resistance by modifying/closing sub-surface porosity. This is a good result but testing these processes on actual parts may be challenging due to complex geometries.

Reviewer 2:

According to this reviewer, the FSP track of the project is making good progress and has demonstrated significant improvements to the fatigue life of samples with a modest increase in hardness (strength) as well. The power ultrasonic-based surface processing (PUSP) is progressing more slowly, but it will be interesting to see what the team accomplishes in the future.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

This reviewer finds that, given the parallel tracks, the level of collaboration is satisfactory. Since the FSP process modifies the surface of a sample while improving bulk mechanical properties, and PUSP is being used for surface modification, it will be interesting to determine whether both can truly operate synergistically in the future.

Reviewer 2:

This reviewer points out that supply of material has been provided by the OEM but that no Tier 1 or 2 suppliers have been involved.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer found that the proposed future work is relevant and believes that it will be particularly interesting to see the applicability of PUSP to complicated thin wall cast parts, and to see the application of FSP by a robotic platform on a prototype part.

Reviewer 2:

This reviewer anticipates completion of the project by end of Fiscal Year 2023 with no new proposed work. The reviewer also is concerned that there is no service provider for product testing.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer points out that the project is aiming to develop technologies to modify/enhance the properties of cast material. This can be an enabler for improved performance and reduced weight.

Reviewer 2:

This reviewer applauds both tracks of this project as directly relevant to the lightweight materials research area as the project is focused on improving properties of component materials, one on the bulk properties specifically, and one on the surface properties.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer believes that the resources seem to be sufficient for the proposed work.

Presentation Number: MAT248
Presentation Title: LMCP P2B - High Intensity Thermal Treatment
Principal Investigator: Aashish Rohatgi (Pacific Northwest National Laboratory)

Presenter

Aashish Rohatgi, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

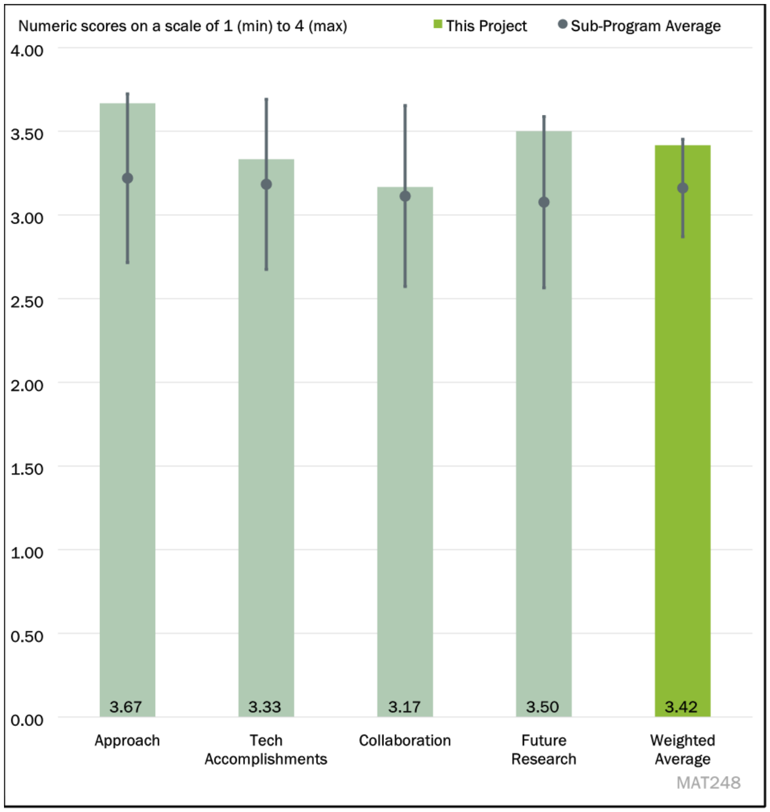

Figure 5-23 - Presentation Number: MAT248 Presentation Title: LMCP P2B - High Intensity Thermal Treatment Principal Investigator: Aashish Rohatgi (Pacific Northwest National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer considers the approach to be an impressive collection of work. The three tasks are well designed, and the appropriate work has been done to answer the relevant research questions that have arisen and move the tasks forward.

Reviewer 2:

This reviewer sees the approach as including far more testing related to the barrier of low-cost than to the barrier of recycling.

Reviewer 3:

This reviewer commends the approach of evaluating processes to improve properties during solidification, post-solidification, and post-heat treatment as a well thought out and generally comprehensive plan. However, it is not clear to the reviewer whether the improvements from ultrasonic intensification during permanent mold casting solidification will carry over to high pressure die casting processes.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer observes significant progress that has made since the previous year. The team has addressed the research questions that arose from its prior years' work and continues to make great progress and has completed or is on the trajectory to complete the previously proposed future work.

Reviewer 2:

This reviewer believes that the project team has made great progress and achieved impressive results with ultrasonic vibration during the permanent mold casting process and peening of finished castings. Heat treatment of prototype castings through Joule heating and fatigue testing of peened cast Al parts remain to be completed.

Reviewer 3:

This reviewer finds it somewhat concerning that Fiscal Year 2023 milestones are just over ½ complete at end of the third quarter of Fiscal Year 2023.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

This reviewer saw evidence of collaboration with ANL using its Advanced Photon Source and ORNL. Equipment from Eck Industries, Sugino Corp. and LSP Technologies was also noted as good by the reviewer.

Reviewer 2:

This reviewer believes that the researchers have effectively leveraged the experimental capabilities of the Advanced Photon Source at ANL and their industrial partners in obtaining large castings from Eck industries.

Reviewer 3:

According to this reviewer, the project team consists of a well-coordinated group of partners from industry and national laboratories working on complementary tasks. The reviewer suggests that the addition of at least one automotive OEM would be desirable to help enable potential commercialization of the technologies evaluated and developed through the project.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer praised the proposed future research as well defined for addressing the remaining challenges and achieving the remaining project milestones by the prescribed end of the project.

Reviewer 2:

This reviewer considers the proposed future research to be sufficient. In-depth analysis of the *in situ* diffraction data will hopefully indicate details of the microstructural refinement mechanism, which is particularly important to this project. The reviewer is eager to see the results from the fatigue tests on the peened material.

Reviewer 3:

This reviewer found a listing of ideas provided with purposes defined in some cases and believes that those with quantitative descriptions appear likely to succeed.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer affirms that the project supports the Materials subprogram.

Reviewer 2:

This reviewer pointed out that the project's efforts are focused on reducing the cost of lightweight Al castings by using local property improvements to meet performance requirements with lower cost secondary Al.

Reviewer 3:

This reviewer said that the project is clearly relevant to the lightweight metals portion within the objectives of the Materials program. The team has been particularly successful with the microstructural refinement thrust. The local heat treatment thrust has identified the issue of blistering, and it will be interesting to the reviewer to see the effects of the local surface peening task on lifetimes.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer found that the number of milestones and the accomplishments appear appropriate for the level of funding.

Reviewer 2:

This reviewer believes that the resources seem sufficient to achieve the stated milestones in the defined timeline and the project team reports that work is on track to achieve the final two milestones.

Reviewer 3:

This reviewer said that the researchers are continually meeting their objectives in a timely manner, such that the level of resources appears to be correct.

Presentation Number: MAT249
Presentation Title: LMCP P2C - Cast-and-Print - AM for Localized Property Enhancement of Al castings
Principal Investigator: Alex Plotkowski (Oak Ridge National Laboratory)

Presenter

Alex Plotkowski, Oak Ridge National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

75% of reviewers felt that the project was relevant to current DOE objectives, 25% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 75% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 25% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

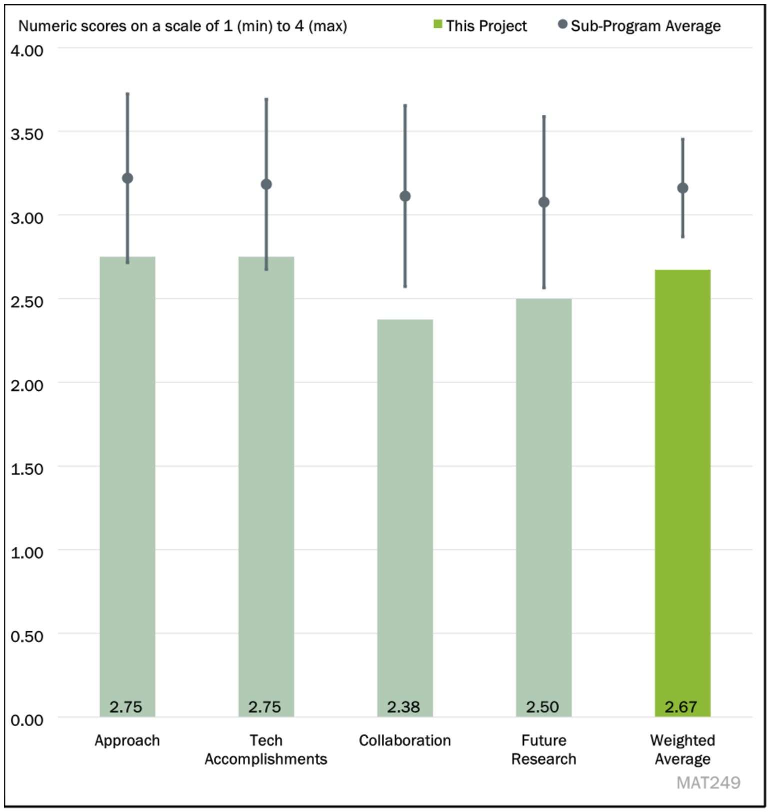

Figure 5-24 - Presentation Number: MAT249 Presentation Title: LMCP P2C - Cast-and-Print - AM for Localized Property Enhancement of Al castings Principal Investigator: Alex Plotkowski (Oak Ridge National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer found that the approach taken by the principal investigators is sound and will lead to addressing the issues being investigated.

Reviewer 2:

This reviewer considers the project to be well designed. Significant technical barriers on printing on cast forms are being addressed at the laboratory scale.

Reviewer 3:

In the view of this reviewer, this is a particularly complicated capability the researchers are trying to develop, and there are still some issues that should be addressed. While work has been described, there is more work to be done to determine the problems that will arise from gas flow during additive manufacturing (AM) on complicated part geometries. Any change to a geometry will change the local flow, and potentially lead to unexpected results in the print. The reviewer thought that the team was going to study this in the previous year. This is in addition to the issues with porosity seen in the substrate in the rivet tabs.

Reviewer 4:

This reviewer asserts that the work performed does not address the project objective and barriers. According to the reviewer, the unstructured approach resulted in disarrayed results and an ineffective use of funds.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer lauded excellent technical accomplishments so far, noting that there are a few issues that the team should consider addressing: (1) Empirical and mathematical evaluations of the residual stresses (and strains) in the deposited material. Visual inspection, as the team has done, is a great first evaluation for the damaging effect of residual stresses, strains, and materials deformation. However, other methods need to be employed to fully evaluate and quantify these materials' conditions. According to the reviewer, any issues missed will likely show up during service. It is preferable to identify them at this stage of research to forestall unfavorable surprises that may appear in the field testing. (2) Cost analyses of the manufactured geometries, to confirm that cost was indeed reduced (as per the project objectives). The reviewer believes that analyses should also be presented to show that the other objectives of minimizing cycle time and reducing the impact of recycle streams were actually achieved.

Reviewer 2:

There is progress being made on what is a difficult task, according to the reviewer. While the geometry of the rivet tabs is quite simple, it would help to demonstrate some of the promise of this capability. The model validation for the AM Al 4047 and any weld consumable material foreseen as useful is important given the cooling rates in the AM process, many passes, etc. The reviewer would like to have some sort of deliverable described regarding this effort.

Reviewer 3:

This reviewer suggests that it would be good to see the interface performance against other joining approaches to establish the improvement provided by print-on-cast over joining two parts of the alloys of interest.

Reviewer 4:

This reviewer complained that the accomplishments were few and unsuccessful. The results indicate that the local properties cannot be modified using a wire additive which is previously known to be incorrect.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

This reviewer found it promising that the team identified the rivet tab as a demonstration geometry, although it seems that the collaboration with industrial partners is minimal. It may be unavoidable given the TRL of the capability. However, if the model validation results for the precipitation kinetics are delivered, it will be particularly useful for future AM capabilities.

Reviewer 2:

This reviewer feels that, apart from listing the collaborators on Slide 14 and identifying that a Mazak machine is used in this work, not much else was mentioned about the contribution of each collaborator in this work. One assumes that the collaborations and synergies are deeper and more extensive than the presentation suggests.

Reviewer 3:

This reviewer desires that the team present more details regarding how the project interacts with the LMCP framework (for example Thrust 4) and the frequency of discussions with OEMs on the relevance of the process being developed.

Reviewer 4:

This reviewer sees minimal results overall and no results associated with collaboration outside of ORNL.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer considers the researchers to have been successful, thus far, in identifying and addressing some of the issues that have arisen during the difficult process of performing AM on cast components. The proposed milestone for a feasibility assessment is maximally suitable. Clearly, this capability shows great promise, but needs a very large effort to become fully developed. AM leads to defects, microstructures, bulk, and surface features and properties that are unexpected, and depending on the alloy system, will continue to be far from a solved problem, in the view of the reviewer.

Reviewer 2:

This reviewer refers back to Question 1 for suggestions for future work that the team should consider.

Reviewer 3:

This reviewer opines that more details are needed on how computational tools will be used for process optimization. Current research details how computation was used for material modeling only.

Reviewer 4:

This reviewer said that future milestones were presented, but no details were provided to justify proceeding.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer believes that, if successful, this work will contribute towards the lightweighting and performance improvement of Al castings for vehicles.

Reviewer 2:

This reviewer finds that the project fits directly with the goals of Materials technology subprogram and is directly applicable to lightweight (and other) materials systems. It will lead directly to new and improved manufacturing capabilities.

Reviewer 3:

This reviewer opines that the VTO Materials subprogram objective is to use wire additive to modify microstructure and geometry of formed Al sheet to enable advanced structural designs for lightweighting including local microstructure modification for improved properties and local chemistry modification to enable subsequent operations (e.g., joining). The VTO objectives are relevant. However, this project did not address the VTO Materials subprogram objectives to enable lightweighting, locally modify microstructure to improve properties, nor enable subsequent operations like joining.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

Project has sufficient resources in this reviewer's estimation.

Reviewer 2:

This reviewer confirms that the resources for the project are sufficient. However, in order to make AM a predictable, straightforward step in a manufacturing process, there is a significant amount of research and work to be done, far more than could be accomplished in a single project.

Reviewer 3:

This reviewer complained that vital information is missing for a proper evaluation of whether the funding in hand will suffice for the team to complete the work.

Reviewer 4:

This reviewer pointed out that there were ten ORNL persons listed on the title slide, but very little research efforts reported.

Presentation Number: MAT250
Presentation Title: LMCP P3A - Cast Magnesium Local Corrosion Mitigation
Principal Investigator: Vineet Joshi (Pacific Northwest National Laboratory/Oak Ridge National Laboratory)

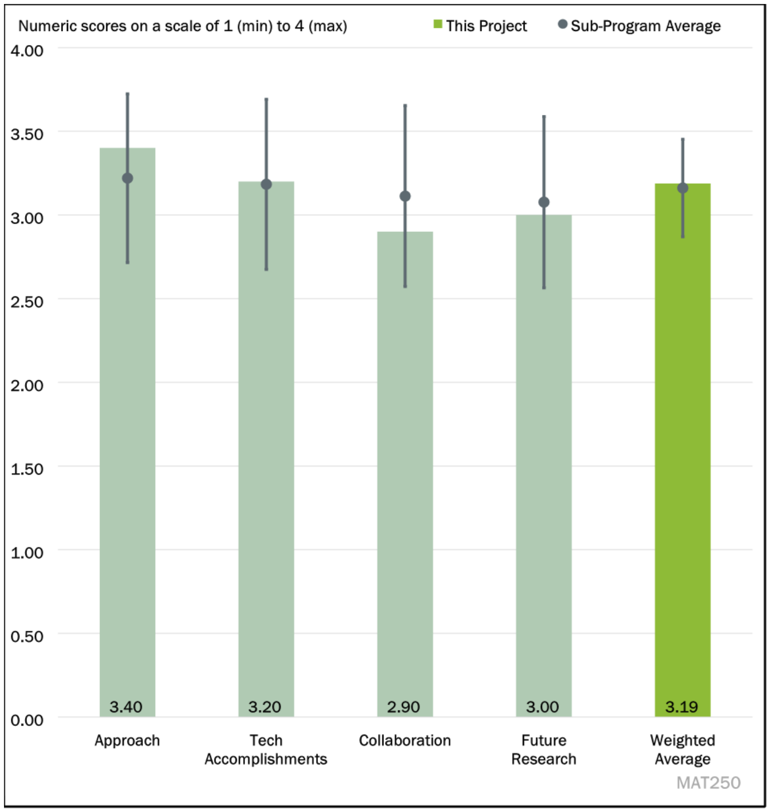

Figure 5-25 - Presentation Number: MAT250 Presentation Title: LMCP P3A - Cast Magnesium Local Corrosion Mitigation Principal Investigator: Vineet Joshi (Pacific Northwest National Laboratory/Oak Ridge National Laboratory)

Presenter

Vineet Joshi, Pacific Northwest National Laboratory/Oak Ridge National Laboratory

Reviewer Sample Size

A total of five reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer thinks that the approach of this project was well thought out because each of the various processes is being investigated by the laboratory process owner with the specific capabilities for its development. This is being accomplished while using the same experimental material which was fabricated via commercially-relevant processes. One point in particular which the reviewer found interesting in relation to feasibility was the amount of work accomplished, given the relatively low amount of funding over the life of the project. Given that the project is focusing solely on coupon level experiments, the reviewer found the electrochemical potential measurements to be a satisfactory means to evaluate the surface processing methods.

Reviewer 2:

This reviewer pointed out that the parallel projects have shown progress on their well-defined milestones. It remains to be seen how effective the coatings are when applied to components with realistic shapes, but the team is in the process of evaluating this.

Reviewer 3:

This reviewer believes that the approach contributes to overcoming barriers.

Reviewer 4:

This reviewer believes that the project is a good one; however, the reviewer thinks that the project could have merited more planning in the following areas: (1) The selection of the surface modification/coating technologies has not been well explained/justified. Silane coatings are already known to be effective. It is difficult to see how the reactive coating based on Li-salt has been selected among all coating/surface modification technologies developed. Cold spray can be very difficult for complex shapes. (2) The beginning of the project should have selected/identified applications for each technology and should have identified performance requirements for each coating used in the applications (galvanic corrosion, general corrosion, wear). These can be generic applications identified by the industry. For example, for galvanic couples, coatings may not be desirable on Mg since any defect would lead to accelerated galvanic corrosion. (3) Much time has been spent on coupon or single particle-level studies. The reviewer thinks that coupon level studies should be conducted by academia in close collaboration with the national laboratories. Academia can conduct in-depth materials analysis and train highly qualified personnel for the industry. The national laboratories can then devote more resources and time on the transfer of the technology to actual applications (industrial parts, complex and larger shapes) in close collaboration with the industry.

Reviewer 5:

This reviewer felt that some more general discussion of issues with the volatility of Mg might be helpful.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer noted that the monthly milestones appear to be on track.

Reviewer 2:

This reviewer observed that, at 75% completion, the amount of fundamental investigation and progress is commensurate with the available funding levels. This project is a very good example of what can be accomplished with a relatively low funding level yet coupled with a relatively narrow focus. The reviewer finds these types of focused, low MRL projects to be significantly more meaningful that those that attempt to cover a broader topic.

Reviewer 3:

This reviewer commented that both parallel projects have shown that surface corrosion and/or wear properties are enhanced with the different coatings. There is adequate and well-done characterization information collected to elucidate the properties of the coatings. The modeling of the cold spray will help with understanding the coating process and properties from the microstructure generated in the film.

Reviewer 4:

This reviewer found that the accomplishments are effective.

Reviewer 5:

This reviewer said that coupon level studies have achieved most of their goals, but corrosion evaluation needs to be completed. Zn coatings on curved automotive shape have been evaluated but scale up of other technologies and transfer to real components remain as challenges.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

This reviewer recounted that collaboration with ORNL, ANL, Applied Research Laboratory at Pennsylvania State University, Meridian Lightweight Technologies and PlasmaTreat Inc. had been noted and the topics assigned to each had been listed.

Reviewer 2:

This reviewer found an appropriate level collaboration between the researchers given the parallel track tasks of ORNL and PNNL. The laboratories have received components from industrial partners that they have sectioned and are now using for coating on more representative samples, so there is adequate collaboration with industrial partners as well.

Reviewer 3:

This reviewer lauded a good demonstration of collaboration and coordination.

Reviewer 4:

This reviewer found that the collaborations between laboratories is good but the collaborations with the academia and the industry can be further developed.

Reviewer 5:

According to this reviewer, aside from the common base material used by ORNL and PNNL, the unstructured added value of collaboration is not readily apparent in this project. However, the reviewer does not know that it is necessary for this project, thus, a lower rating for this question could be a bit unfair.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer considers that the proposed future work is appropriate.

Reviewer 2:

This reviewer identified a listing of ideas provided with purposes defined and, in some cases, given qualitative description, but found it difficult to determine the likelihood of success.

Reviewer 3:

This reviewer believes that the proposed future research is significant and in line with what is necessary to develop these technologies to the next level of manufacturing readiness. However, they are not in line with the available funding based upon the reviewer’s experience in developing new processes. Regardless, the value of this work is apparent and the identified topics for future research may help to draw in external collaborators.

Reviewer 4:

This reviewer credits that the researchers are aware of many of the challenges that will arise during scale up but identifies one significant issue that the reviewer believes should be considered, which is galvanic corrosion.

Reviewer 5:

This reviewer believes that more emphasis can be placed on scale-up.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer affirmed that the project is relevant to the Materials subprogram.

Reviewer 2:

This reviewer notes that corrosion and wear mitigation are important challenges in lightweight vehicle construction.

Reviewer 3:

This reviewer points out that development of surface modification processes for lightweight materials such as Mg addresses one issue for moving this lightweighting material towards industrial applications, whereupon its implementation would support mass savings and, thus, reduction of GHG emissions, in addition to increasing the range for EVs by such mass savings.

Reviewer 4:

This reviewer believes that the project will lead to improved corrosion and wear properties, so it is relevant to the Material technology subprogram.

Reviewer 5:

This reviewer confirms that the work is relevant to the Materials subprogram.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer feels that the number of milestones and the accomplishments appear appropriate for the level of funding.

Reviewer 2:

This reviewer thinks that the resources seem to be sufficient or even excessive as only long-term corrosion and wear studies remain to be conducted.

Reviewer 3:

This reviewer believes that this project has accomplished a significant amount of value-added work with the relatively small budget allocated over the period of this project.

Reviewer 4:

According to this reviewer, the support for the project appears to be sufficient; the team was able to meet its milestones and also to leverage results from other projects.

Reviewer 5:

This reviewer stated that the resources applied are sufficient.

Presentation Number: MAT251
Presentation Title: LMCP P3B - Thermomechanical Property Modification of Mg Castings
Principal Investigator: Mageshwari Komarasamy (Pacific Northwest National Laboratory)

Presenter

Mageshwari Komarasamy, Pacific Northwest National Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

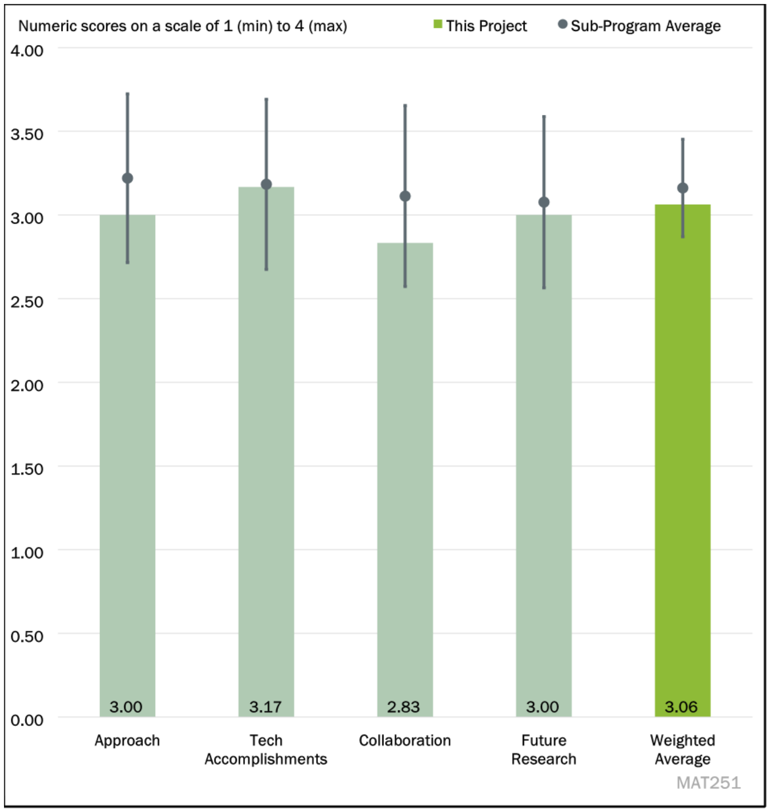

Figure 5-26 - Presentation Number: MAT251 Presentation Title: LMCP P3B - Thermomechanical Property Modification of Mg Castings Principal Investigator: Mageshwari Komarasamy (Pacific Northwest National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer considers the project to be well designed to address technical barriers.

Reviewer 2:

This reviewer considers the primary barrier that remains is applying the FSP technique to realistically shaped components with large curvatures and small radii of curvature. While the team has been successful on 15^{o} parts, it would still be useful for the team to successfully apply FSP to complicated shapes. The team has proposed to apply FSP on 45/90^{o} coupons in future work, but it is still unclear if this will be successful or not.

Reviewer 3:

The reviewer finds that the Mg materials knowledge behind this project is limited and background in microstructural evolution in FSP is somewhat lacking. Microstructural evolution in the FSP and the affected zones needs to be evaluated and related to hardness. According to the reviewer, it cannot be assumed that FSP only mechanically refines the intermetallic phase; increase in temperature will lead to partial dissolution and even to reprecipitation. There may be recrystallization so electron backscatter diffraction analysis would also be desirable to the reviewer.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer praises the researchers for continuing to show impressive results. The increases in fatigue life in the FSP regions of the samples are extremely promising. The differences in properties between the FSP region, a heat affected zone (if there is one), and the surrounding material may lead to issues with real components, so this should be kept in mind for real geometries. Also, the researchers mentioned using different shapes of tooling. The team should be aware that the flow pattern in the weld nugget will change with different tooling and may lead to different properties, particularly fatigue properties. But, overall, the work shows great promise, according to the reviewer.

Reviewer 2:

This reviewer stated that progress has been made and the efforts have been effective.

Reviewer 3:

This reviewer noted that FSP has increased the fatigue performance of AM50 which is a major achievement. It seems that the calcium alloy did not provide additional improvement to fatigue performance.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

To this reviewer, the project partners appear to be working in collaboration.

Reviewer 2:

This reviewer commented that the collaboration between the laboratory partners, PNNL, ORNL, and ANL is good. It was unclear how closely they are communicating with industrial partners beyond receiving material from them. Hopefully, the proposed milestone for demonstration on a complex geometry without flaws can provide a demonstration that FSP can be applied to real components effectively.

Reviewer 3:

Collaboration exists but it is hard to evaluate since ORNL and ANL tasks are not presented.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This work has shown to the satisfaction of this reviewer that fatigue life can be significantly improved through FSP. Demonstrating this on a real component would be an impressive milestone, and the proposed future work is the next step in achieving this goal. While not related to the current research thrust, the researchers should at least keep in mind that if they are depositing a different, stronger alloy, which they showed, they may need to consider the effects on corrosion properties, particularly galvanic corrosion, depending on the deposited alloy.

Reviewer 2:

This reviewer said that the proposed future work is appropriate.

Reviewer 3:

This reviewer was concerned that some aspects, such as corrosion evaluation, are not in the future plan. A scale-up to complex shapes is planned which is, of course, appropriate next step of the project.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer finds that the technology contributes to the ability to use lightweight Mg in vehicle construction.

Reviewer 2:

The reviewer believes that the project is relevant to the Materials technology subprogram and is directly supporting the VTO subprogram objectives, as it is improving the mechanical properties of Mg significantly. The researchers have shown impressive improvements to the fatigue life of friction stir processed samples.

Reviewer 3:

This project supports the overall VTO materials sub-program.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer affirmed that the resources are sufficient to achieve milestones.

Reviewer 2:

According to this reviewer, though many details were not included in the presentation, there seems to be sufficient funds for scaling up to complex shapes.

Reviewer 3:

This reviewer believes that the next step in this project will likely be rather difficult to achieve, but the resources seem to be sufficient, as the team continues to make progress on its milestones.

Presentation Number: MAT252
Presentation Title: LMCP - Thrust 4 - Materials Lifecycle
Principal Investigator: Jeff Spangenberger (Argonne National Laboratory)

Presenter

Jeff Spangenberger, Argonne National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

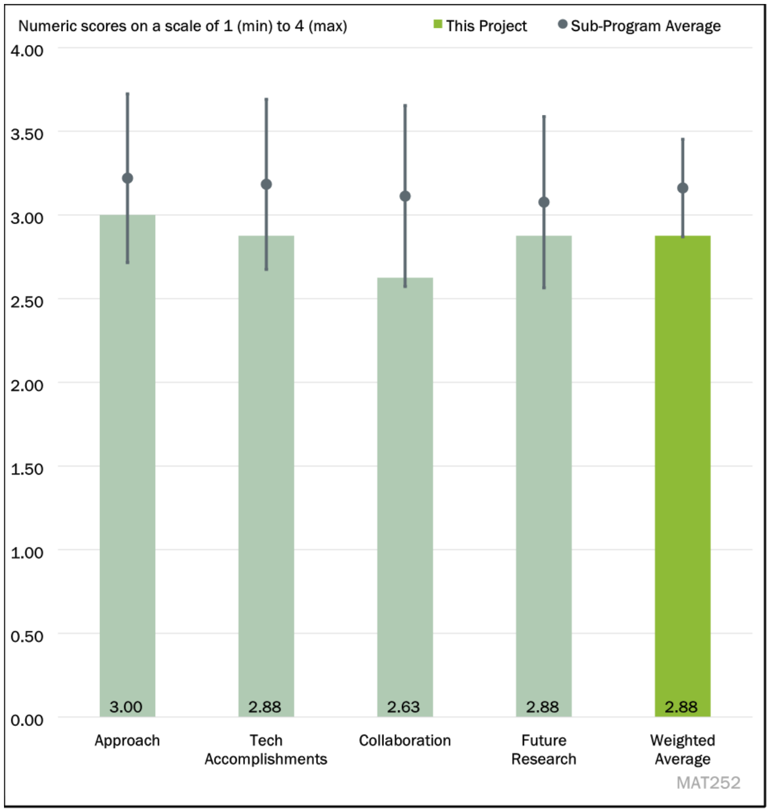

Figure 5-27 - Presentation Number: MAT252 Presentation Title: LMCP - Thrust 4 - Materials Lifecycle Principal Investigator: Jeff Spangenberger (Argonne National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This project seemed to this reviewer to be more focused this year than at the time of the last review. Its modeling focus is attractive for including secondary alloys and understanding their impact on GHG emissions.

Reviewer 2:

This reviewer said that the technical barriers are being addressed.

Reviewer 3:

This reviewer believes that the project has a good approach.

Reviewer 4:

The technical barriers of the project were slightly unclear to this reviewer. There are, of course, many alloys and there will be more as new or modified alloys are developed by companies such as Tesla or Alcoa. The reviewer suggests that scrap generated perhaps can be recycled into master alloys that the alloy producers can use.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer considers that the project is on target to meet milestones.

Reviewer 2:

This reviewer approves of the life cycle analysis (LCA) tool that has been developed as an excellent start to the recycling of automotive scrap.

Reviewer 3:

This reviewer is satisfied that the project is making generally effective progress.

Reviewer 4:

This reviewer commented that the state of the art has been quantified but with few of the new technologies developed in LMCP being incorporated for comparison. It would have been beneficial to understand the basis for the modeling framework.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The project partners are collaborating effectively, in the view of this reviewer.

Reviewer 2:

The connection to the rest of ongoing LMCP work seemed somewhat tenuous to this reviewer.

Reviewer 3:

This reviewer believes that the project team seems to be meeting with collaborators regularly; however, the latest progress from other LMCP projects is not being incorporated regularly to assess its results over the state of the art.

Reviewer 4:

The reviewer assumes that the collaboration does exist; however, it was not explained in the presentation to the satisfaction of the reviewer.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer anticipates that completion of the model will be useful when available to the community.

Reviewer 2:

This reviewer believes that the project is scoped to address future targets.

Reviewer 3:

This reviewer found the approach to develop the tool that helps easily see cost and environmental impacts related to recycling to be good.

Reviewer 4:

This reviewer is concerned that the future work seems to be constrained by the challenges related to obtaining data and information from the industry.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer affirms that the project work supports the lightweighting mission of the Materials subprogram.

Reviewer 2:

This reviewer points out that recycling automotive scrap is of high importance to enable the cost-effective use of light metal alloys in vehicle construction.

Reviewer 3:

This reviewer finds the project is aligned with the VTO Materials subprogram for materials.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

To this reviewer, for a modeling focused small effort, the resources are sufficient.

Reviewer 2:

Noting that the future work involves discussions with the collaborators and the industry and the completion of the LCA tool, the reviewer finds that the funds are sufficient.

Reviewer 3:

This reviewer believes that sufficient resources are employed to deliver the milestones.

Reviewer 4:

This reviewer finds that sufficient resources are available.

Presentation Number: MAT254
Presentation Title: Conductive Lightweight Hybrid Polymer Composites from Recycled Carbon Fibers
Principal Investigator: Yinghua Jin (RockyTech, Ltd.)

Presenter

Yinghua Jin, RockyTech, Ltd.

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

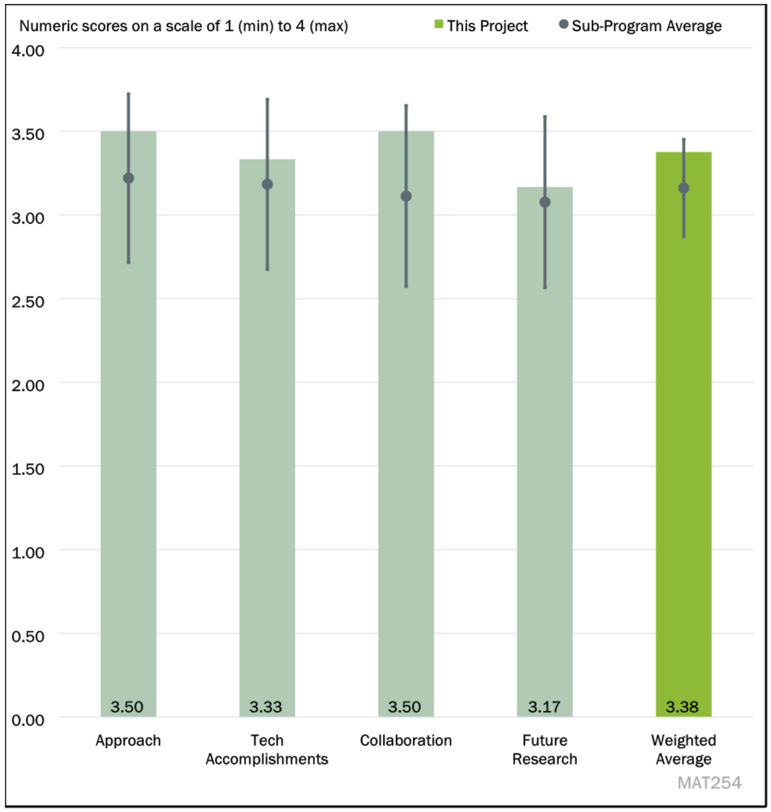

Figure 5-47 - Presentation Number: MAT254 Presentation Title: Conductive Lightweight Hybrid Polymer Composites from Recycled Carbon Fibers Principal Investigator: Yinghua Jin (RockyTech, Ltd.)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer believed the project is well designed and well planned with a focus on the development of recyclable nano-and micro-filler reinforced vitrimer composites made from recycled milled carbon fibers (NMVC-R2) that have combined lightweight, high mechanical properties, and electrical conductivity. The claimed innovations are (1) the use of repressible and recyclable vitrimers with recycled milled carbon fibers lowers the overall production cost and (2) combined use of micro and carbon-based nanofillers to counterbalance the disadvantages of individual reinforcing fillers that synergistically improves mechanical strength and electrical conductivity of the materials.

Reviewer 2:

According to this reviewer, the project addressed a critical issue in the automotive industry by developing recyclable vitrimer composites made from recycled milled CFs that have combined lightweight, improved mechanical properties, and electrical conductivity. The approach and timeline are reasonable to the reviewer.

Reviewer 3:

This reviewer found that the approach provides a direct pathway for recovery and re-use of premium fiber reinforcement materials. However, the return on investment is not clear to the reviewer when considering composites reinforced with low-cost materials such as glass fiber. Therefore, the project team should verify the transactions cost analysis predictions recognizing that CF composites represent only a small fraction of polymer composite usage in automotive applications.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1: .

This reviewer noted that the team has developed NMVC-R2 composites through a solution-impregnation method or a solid-phase powder compression method. The team introduced combining nano- and micro-fillers leading to significant improvements in tensile modulus and electrical conductivity. The technical achievements of the team are that they (1) improved the interface adhesion between the fillers and polymer matrix through covalent surface modification of CF micro fillers with carbon-based nanofillers, (2) improved the conductivity of the NMVC-R2 composites through the formation interconnected network of conductive carbon-based nanofillers, and (3) enabled reprocessibility and recyclability of NMVC-R2 composites by using vitrimers in the polymer matrix. The tensile stress-strain curves show that the repaired sample exhibits a comparable modulus to that of the original sample; however, there was a considerable decrease in the tensile strength and elongation at break indicating the repair efficiency still needs to be improved.

Reviewer 2:

The project has completed all the milestones through June 2023 and the results are promising because they show improved mechanical and electrical properties with the addition of their nano-micro reinforcements in the recyclable matric. The reviewer does not have any concerns about the progress of the project.

Reviewer 3:

This reviewer considered that the results from the project show good progress against the objectives with demonstrations for repeated recovery and recycling of the CFs. Likewise, improvements in electrical conductivity were reported, albeit at levels that may not be suited to any practical application.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

According to this reviewer, the project team demonstrated good communication across the partners towards meeting the goals of the program.

Reviewer 2:

This reviewer shared that the team is led by RockyTech in partnering with the two teams at the University of Colorado - Boulder. Individual roles were described.

Reviewer 3:

This reviewer noted that the team worked with the University of Colorado - Boulder and the presenter clearly described which part of the project was done at the university.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer saw the proposed work as being essential in determining suitability for the materials that need a V-0 flammability rating. The cost model should also make a comparison to glass reinforced composite materials as CF may not be an appropriate benchmark.

Reviewer 2:

This reviewer found the future work to be well described based on the teams' achievements including higher mechanical properties, scale-up process, feasibility in EMI shielding, study of the failure mechanism by tension, and three-point bending by experimental and computational modeling. The reviewer recommends having a reliability test with enhancing fewer defects or defect-free NMVC-R2 composites.

Reviewer 3:

This reviewer stated that, although the barriers and challenges were mentioned, no specific future task slide was provided.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer affirmed that the project goals are aligned with the VTO mission statement.

Reviewer 2:

The scope of work is well aligned with the overall VTO Materials subprogram objectives, according to this reviewer.

Reviewer 3:

This reviewer considered that the project is well aligned with the overall objectives of VTO.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer was satisfied that the team has made good progress with the resources currently deployed.

Reviewer 2:

This reviewer believed that the team has sufficient resources to carry out the planned tasks.

Reviewer 3:

The project is appropriately funded, according to the reviewer, who believes that the resources are sufficient to achieve project goals in the stipulated time.

Presentation Number: MAT256
Presentation Title: Game Changing Resin/Coating/Adhesive Technology for Lightweight Affordable Composites
Principal Investigator: Scott Lewit (Structural Composites, Inc.)

Presenter

Scott Lewit, Structural Composites, Inc.

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 50% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 50% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

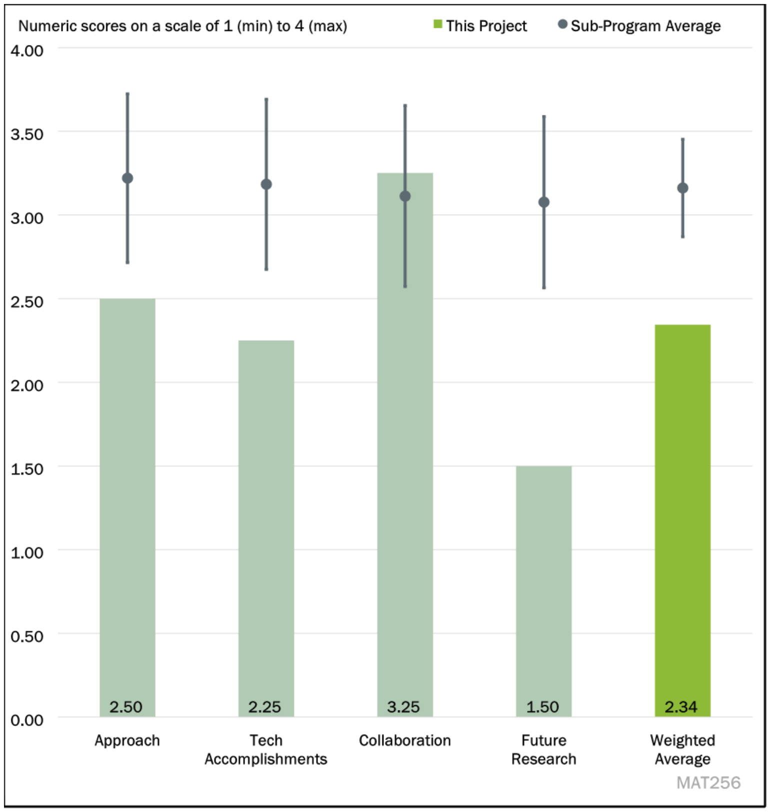

Figure 5-48 - Presentation Number: MAT256 Presentation Title: Game Changing Resin/Coating/Adhesive Technology for Lightweight Affordable Composites Principal Investigator: Scott Lewit (Structural Composites, Inc.)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The approach is reasonably well designed to this reviewer although it appears to be a little more focused on marketing the concepts demonstrated in previously commercialized heavy vehicle applications to the automotive market rather than on technical investigation. The reviewer wrote that potential advantages to the approaches are identified whereas discussion of the barriers is sparse.

Reviewer 2:

This presentation had very little information on the actual work being performed according to the reviewer. The reviewer was unclear on what the team seeks to accomplish and what technical barriers exist.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer complained that several product forms with varying amounts of polyurethane have been identified by the team as being evaluated, but real data (other than announcing specific product forms) are pretty scarce, especially in judging cost versus performance. Adhesive performance of the gel coating approach does surpass paint by up to 25% in some of the product forms, as would be expected. Abrasion resistance is higher, but data presented only as total weight loss without testing reference data is hard to evaluate.

Reviewer 2:

This reviewer felt that the team has made little progress in the Phase I project and is unclear on whether any progress has been accomplished.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

This reviewer praised the teaming members as very strong.

Reviewer 2:

This reviewer commented that, while Structural Composites, Inc. is tapping into good resources in terms of materials and testing service suppliers, the reviewer is unclear about how much collaboration and feedback is actually being exchanged with Ford as a partner during execution of this Phase of the project. The reviewer would be interested in Ford's perspective on value/likelihood of replacing paint with gel coating in automotive applications. Out-of-paint-booth processing is touted in several places, but Ford's endorsement that this would be preferable to any new needs required for handling increased polyurethanes as a replacement would be encouraging.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

Discussions on barriers and plans for development and evaluation could be improved because they were not given much detail other than a very general listing of broad areas such as manufacturability, performance, damage tolerance, etc.

Reviewer 2:

The future work proposed is not clear.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

According to this reviewer, pathways for automotive utilization of some of the approaches identified can be seen, but it would have been useful to have more information on what is assessed as barriers and planned activities to address them.

Reviewer 2:

Lightweighting is important for future vehicles, in the opinion of this reviewer.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The resources appear to this reviewer to have been adequate to complete this Phase 1. The reviewer will be interested to see how this progresses in successive phases, if funded.

Reviewer 2:

It is unclear to this reviewer what the goals of this project are and what has been accomplished towards them.

Presentation Number: MAT257
Presentation Title: Changing the Design Rules of Rubber to Create Lighter Weight, More Fuel Efficient Tires
Principal Investigator: Kurt Swogger (Molecular Rebar Design, LLC)

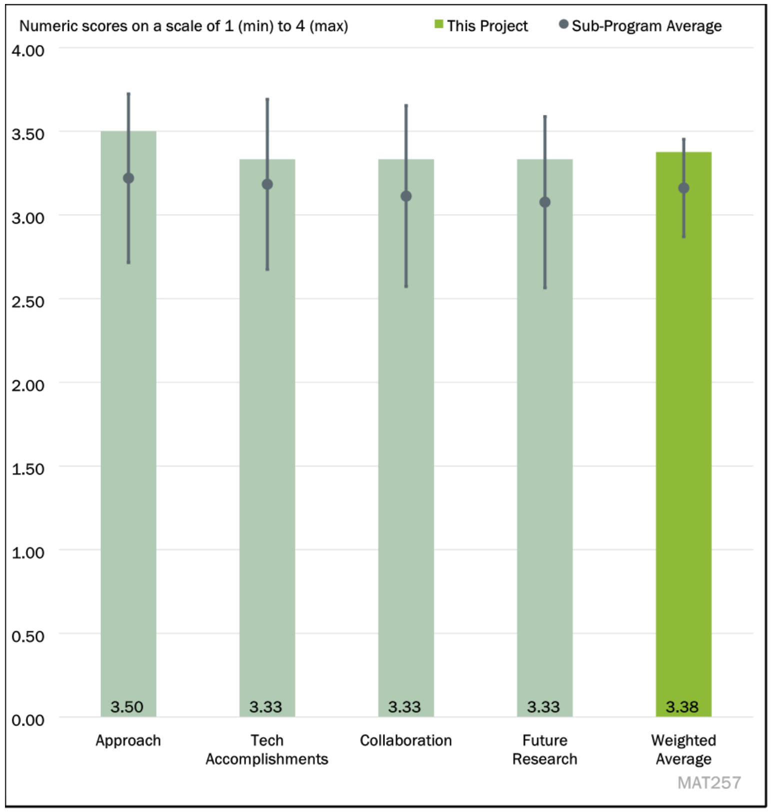

Figure 5-49 - Presentation Number: MAT257 Presentation Title: Changing the Design Rules of Rubber to Create Lighter Weight, More Fuel Efficient Tires Principal Investigator: Kurt Swogger (Molecular Rebar Design, LLC)

Presenter

Kurt Swogger, Molecular Rebar Design, LLC

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer applauded the project as well designed and well planned with a focus on the development of covalently bonded carbon nanotubes (Molecular Rebar® [MR]) for tire polymers with an improved lifetime of tread and rolling resistance of tread compound.

Reviewer 2:

This reviewer noted that the project aims to incorporate CNTs into tire materials to improve their performance, which the reviewer finds to be a novel approach. The goals are realistic but still very impactful if achieved. The levelized cost of energy and energy saving estimates are very impressive to the reviewer.

Reviewer 3:

Project has a good approach for using CNT-bonded rubber for improving tire durability.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer described how, in Phase 1, the team developed novel silane-functionalized and covalently-coupled molecular rebar CNTs for rubber and coupled silane moiety to OH/COOH groups of multi-walled CNTs. The team produced laboratory-scale silane MR in potential carrier agents and completed compound and test experimental silane-MR product and determined the most effective product form by optimizing dispersion, performance properties, and ease of manufacture process.

Reviewer 2:

This reviewer remarked how initial results showed novel silane functionalized and covalently coupled CNTs for rubber with improved lifetime and reduced composite density of 5%-7%. Initial results are found promising by the reviewer to support the project for a second phase.

Reviewer 3:

This reviewer observed that good technical results were presented. Knowing the ASTM/ISO standards used for testing material performance would have been helpful.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

This reviewer commended that the OEM and tier 1 suppliers are working together to commercialize the technology.

Reviewer 2:

This reviewer lauded an excellent team with great commercial partner engagement.

Reviewer 3:

The reviewer pointed out that the team is led by Molecular Rebar Design LLC, partnering with the Goodyear Tire and Rubber Co. and Arlanxeo. The reviewer is unclear about how these other companies contributed to the outcomes obtained in Phase 1.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer described how, in the proposed future research in Phase 2, the team will develop “Guiding Principles” and develop and test prototype tires with Goodyear. The team will focus on (1) establishing optimum replacement ratios of silane-MR via masterbatch for incumbent silica fillers, (2) performing additional experimental formulations to determine the efficacy of alternative coupling agents and elastomers, and (3) continuing to provide silane-MR masterbatch for tire manufacturers’ evaluations.

Reviewer 2:

Future tasks are seen by the reviewer as well aligned with the project objective, and, therefore, the reviewer believes that the project is progressing effectively.

Reviewer 3:

This reviewer found the approach for achieving Objective 2, especially assessing industrial adoption of the material choices, is not clearly defined.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer saw that the scope of work is well aligned with the overall VTO Materials subprogram objectives.

Reviewer 2:

The project, as described by the reviewer, aims to reduce rolling resistance and tire weight, leading to improved EV energy efficiency. The project is relevant for VTO due to its impact on reducing energy use per mile, reduced costs for electrified fleets, and global energy savings.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer believed that the team has sufficient resources to carry out the planned tasks.

Reviewer 2:

The project has sufficient resources to achieve the proposed goals, according to this reviewer.

Presentation Number: MAT259
Presentation Title: Green Composites Fabricated from Bacteria Retted Bast Fiber and PLA for Light Weight Vehicle Components
Principal Investigator: Lee Smith (Z&S Tech, LLC)

Presenter

Lee Smith, Z&S Tech, LLC

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

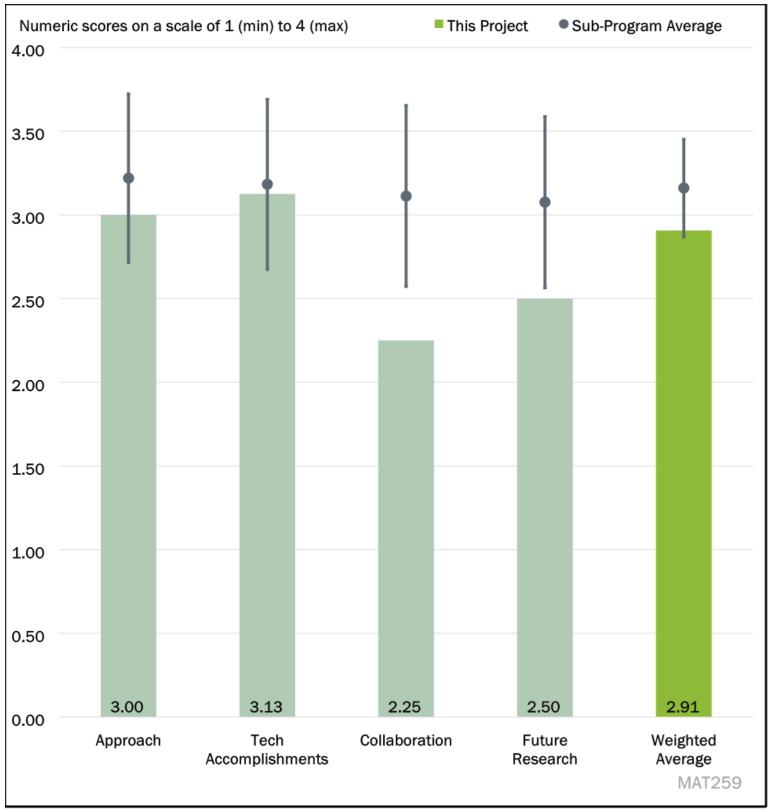

Figure 5-50 - Presentation Number: MAT259 Presentation Title: Green Composites Fabricated from Bacteria Retted Bast Fiber and PLA for Light Weight Vehicle Components Principal Investigator: Lee Smith (Z&S Tech, LLC)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer commended the work as uniquely focusing on VTO goals by attempting to better manufacture a different type of fiber mat and addressing the technical challenges. As such, the work is primarily focused on making enhanced fibers. The work has also incorporated a LCA early in the project to show its benefit, which the reviewer considers a strong approach. The work could benefit from baselining the composites' performance to other known materials and noting their performance benefits. Additionally, a clearer naming system or presentation of the mechanical data would be helpful to the reviewer.

Reviewer 2:

The approach is interesting to this reviewer; however, the reviewer professed to have little knowledge of this field and declined to comment on the potential impact.

Reviewer 3:

This reviewer described how the work featured self-cultured bacteria retted bast fiber material (BFM) with a view toward sustainable composite solutions. Apparently BFM is more environmentally friendly, lower in energy consumption to produce, and more economical and relevant to DOE metrics of lower embodied energy. The team used flax fiber to demonstrate the bacteria retting, produced fibers for composites, made composites, and tested them for different properties. The average fiber fraction was approximately 50% in the composites. The mechanical test data was compared within the variants and found marginally different. The team did not compare this data to available literature for benchmarking, which is a weakness of the study in the view of the researcher.

Reviewer 4:

This project is described by the reviewer as addressing sustainability needs for automotive composites by use of bacteria retted hemp fiber-reinforced polylactic acid (PLA) composites. However, it is not clear to the reviewer how the original hemp fibers were collected from hemp stalk. The initial processing would be a key factor for bacterial retting of those fibers, which essentially loosens the fiber bundles presented in the original feedstock, according to the reviewer. The reviewer is not convinced that the process will yield economic advantages because the process is very slow and will require 2-4 weeks. Also, the process will still need a lot of water processing. (The process may not necessarily require wastewater treatment, but the volume of water to be recycled is very high.) The preliminary LCA somehow shows advantages, but the composite properties show poor tensile strength, according to the reviewer.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This work was well designed in the judgment of this reviewer and showed advancement in biological retting, analysis, and material performance. As noted, baselines to vehicles parts to inform future research would be beneficial.

Reviewer 2:

This reviewer believed that the team has made significant progress in Phase I.

Reviewer 3:

This reviewer referred back to prior comments made above, saying that many of them apply. Also, the extended view of the work to engage an OEM/Tier 1 supplier would have provided a real value-proposition to the development of these materials. The studies are good from a scientific standpoint but their utility in practical applications is less clear. The comparisons are within their variants, but there is a need to compare these fibers to other fibers like hemp and other bast fibers and resins (through review of literature at a minimum), according to the reviewer.

Reviewer 4:

The initial work, as described by the reviewer, shows successful bacterial retting of hemp fibers and formation of bast fiber mat. The mat, however, when used for impregnation with a PLA matrix, showed composite properties that were not very appealing. The modulus of the composites is good, but the tensile strength is only as good as the resin’s strength, even after loading with 40%-50% fibers. This data suggest that the fibers are not flawless, are not fully retted, or have been loosened.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer was not sure whether this work really fits for a Phase I SBIR because the work primarily was done by Z&S Tech.

Reviewer 2:

This reviewer found that the teaming arrangements are weak.

Reviewer 3:

This reviewer complained that the slides received by the reviewers had no collaborators listed. Only the lead company was listed as the performer of the work. The reviewer states that if this is a mistake, then the rating should be changed to N/A.

Reviewer 4:

This reviewer asserted that collaboration was not clearly presented, though. it was mentioned that the University of North Texas is involved in this work somehow.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer found no future work was presented and this is at the end of the Phase I.

Reviewer 2:

This reviewer said that future work was not discussed.

Reviewer 3:

This reviewer noted that the work showed an end date of April 2023, so the future work question appears to be irrelevant.

Reviewer 4:

This reviewer noted that any Phase 2 plan slide was missing in the presentation. Only during the Q/A session did the team mention some work to be done in the next phase.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer believed the novel fiber approach to make fibers better and more efficiently is of extreme interest to the VTO Materials subprogram.

Reviewer 2:

Natural materials have the potential for sustainable automotive structures, according to this reviewer.

Reviewer 3:

This reviewer said the work applies to materials development.

Reviewer 4:

This reviewer commented that it is indeed a relevant topic, but the approach needs to be more convincing or appealing.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The resources are sufficient as seen by this reviewer.

Reviewer 2:

This reviewer reported that the team has completed the objectives with the funds supplied.

Reviewer 3:

To this reviewer, it looked as if the team had sufficient resources to conduct the work.

Reviewer 4:

Phase I resources are adequate, according to this reviewer.

Presentation Number: MAT260
Presentation Title: Green Composites from Carbonated Bio-based Oils and Recycled Nanofibers
Principal Investigator: Jesse Kelly (Luna Labs, USA)

Presenter

Jesse Kelly, Luna Labs, USA

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

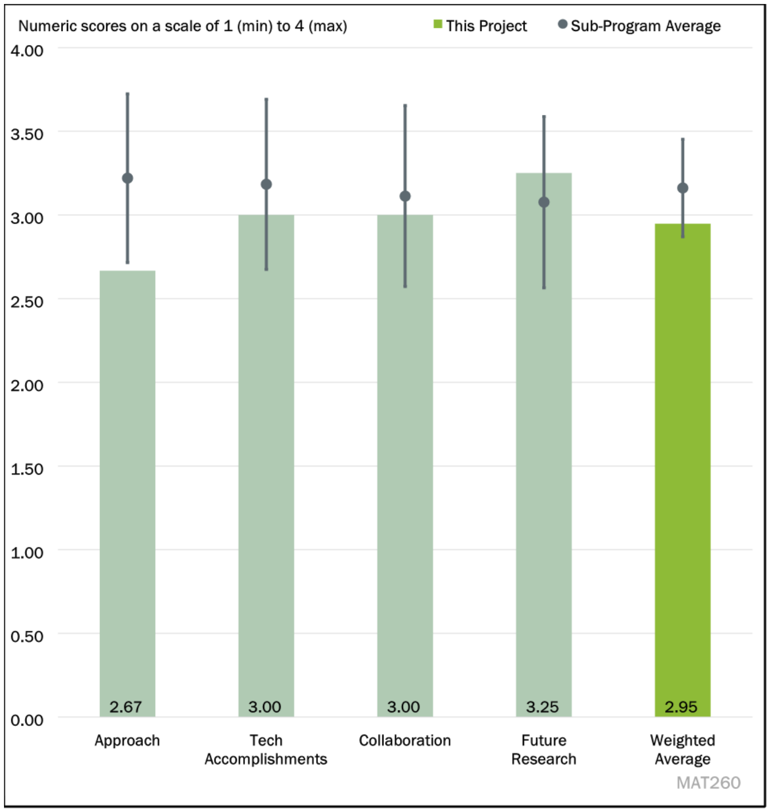

Figure 5-51 - Presentation Number: MAT260 Presentation Title: Green Composites from Carbonated Bio-based Oils and Recycled Nanofibers Principal Investigator: Jesse Kelly (Luna Labs, USA)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer referenced the VTO Materials goal to develop biobased polymer system that also consumes CO_2 and has useful properties. This material looks promising to the reviewer, as compared to ABS for example.

Reviewer 2:

This reviewer found the work (e.g., finding green replacements for today's materials) is strongly motivated; however, the reviewer sees a lot of claims made without significant results to back them up. Such claims include formulations to exceed current baseline properties, biodegradation, processing, and re-carbonization of the material. Importantly, the team should justify why a polyurethane is being used in composite applications and why PP, a cheap commodity plastic, is being used to baseline.

Reviewer 3:

This reviewer believed that the team is trying to do too much for a Phase 1 project. Instead of focusing on composite development, the team should have first focused on the resin development and addressed the Tg and heat deflection issues. Further, according to the reviewer, nanofillers and additives are not improving the strength and modulus that significantly. For use as composites, the material should have at least 10 GPa elastic modulus. The carbonation may not be a catalyst-free process. The reviewer is not sure how the team is expecting 15-30 ring weight percent in the caprolactone matrix because the building block linseed oil has only a few unsaturated moieties.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

Good technical progress was achieved at this phase, as seen by the reviewer, who believes that the approach shows enough progress and results to continue with Phase II.

Reviewer 2:

This reviewer found that the team has met all project goals. However, as noted above, it is difficult for the reviewer to ascertain why the team chose certain material baselines and whether this material will actually be a useful composite for lightweighting. PP and ABS are two materials the team uses as baselines but these materials would be difficult to substitute in current vehicles.

Reviewer 3: .

The caprolactone matrix exhibiting nearly 40 MPa and 1.5 GPa modulus was considered by this reviewer to be a very good result. However, the nanofibers are apparently not showing any significant reinforcement strength. The recyclability potential demonstration shows excellent progress.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The team seemed to this reviewer to have a strong connection with NREL who works well for producing resin and iterating on formulations.

Reviewer 2:

This reviewer found good collaboration between NREL and Clemson.

Reviewer 3:

According to this reviewer, Phase I did not really have a planned collaboration identified by the presenter; however, the reviewer finds that the Phase II collaboration plan is very clear.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

Proposed Phase II formulation studies are appropriate for the material, according to this reviewer.

Reviewer 2:

The Phase II plan was clear to this reviewer. However, the reviewer recommends focusing on resin development first before moving toward composite formulation development.

Reviewer 3:

This reviewer noted that Phase I of the SBIR has ended.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This work did seem to this reviewer to align with the VTO Materials subprogram goals of low-cost fibers and de-carbonizing their manufacture; however, performance baselines are only to thermoplastics and unreinforced plastics requirements and should be better described, according to the reviewer.

Reviewer 2:

This reviewer considered the project to be highly relevant to the VTO goals for CO_2 reduction and sustainability.

Reviewer 3:

This reviewer offered that sustainable composites are highly desired, and the project is relevant to the need for vehicle lightweighting, and sustainability.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The resources seemed sufficient to this reviewer.

Reviewer 2:

This reviewer said that the resources were sufficient for a Phase 1 activity but there is still much work to be done to further develop and evaluate the material.

Reviewer 3:

Resources are adequate in the view of this reviewer.

Presentation Number: MAT261
Presentation Title: Multiscale Bioinspired Enhancement of Natural-Fiber Composites for Green Vehicles
Principal Investigator: Lorenzo Mencattelli (Helicoid Industries, Inc.)

Presenter

Lorenzo Mencattelli, Helicoid Industries, Inc.

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

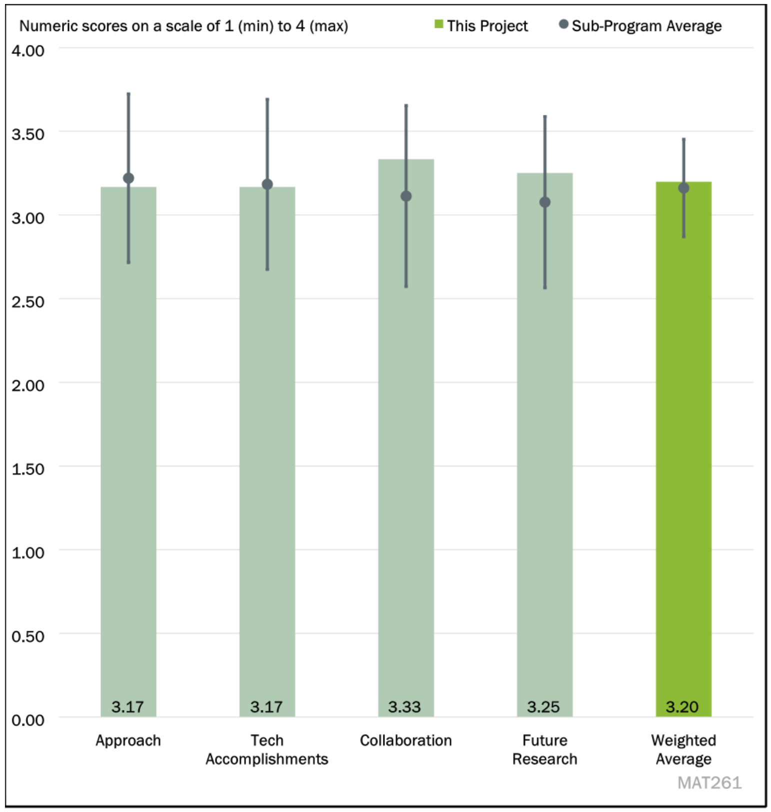

Figure 5-52 - Presentation Number: MAT261 Presentation Title: Multiscale Bioinspired Enhancement of Natural-Fiber Composites for Green Vehicles Principal Investigator: Lorenzo Mencattelli (Helicoid Industries, Inc.)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The project was exciting to this reviewer since it involves flax fiber surface tailoring for improved composite performance with methyl acrylated PP, PLA, and epoxy matrices. The flax fiber surface tailoring approach involving nanoparticle deposition by simple deposition from liquid suspension of particles is basic and scalable. The composites showed excellent performance that is better than traditional glass fiber composites.

Reviewer 2:

This reviewer described how the work presents a method for enhancing the performance of composites through fiber orientation and additives. The bio-inspired approach of this work is not clear to the reviewer even with the bonus slide. More illustrative baseline experiments would be helpful. Overall, though, the project leads to impressive, enhanced performance of the composites relative to glass. Notably, glass is not overtly energy intense, so more analysis would be beneficial to this approach and narrative according to the reviewer.

Reviewer 3:

This reviewer noted that modification to the reference flax composite shows modest improvement using computer numerical control and conjunctive normal form. The glass baseline is not clear to the reviewer and whether chopped glass fiber or fabric was used. The properties look low suggesting chopped fiber was most likely compared to a continuous fiber fabric, which can be misleading, according to this reviewer.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer reported that the composites prepared in this project not only exhibit better mechanical properties but also excellent fatigue resistance. The surface tailoring approach along with helical layering of fibers is an excellent approach that likely caused enhanced performance, according to the reviewer. The team made significant progress and demonstrated more than 90% extended durability.

Reviewer 2:

The project team demonstrated to the satisfaction of this reviewer that its approach can lead to enhanced performance of a bio-composite. More details are necessary, though, to completely understand the approach in a more stepwise fashion.

Reviewer 3:

This reviewer confirmed that the approach shows a slight improvement over baseline flax fabric. The peak impact load looks better but the reviewer has concerns about the damage area.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

This reviewer noted that the project has TPI Composites as a strong partner for the work, which could enable future parts manufacture. The team also clearly lists their collaboration between multiple project partners.

Reviewer 2:

To this reviewer, the project had good team collaboration.

Reviewer 3:

This reviewer indicated that the team has an excellent collaboration plan involving a university, a start-up and scaled-up parts manufacturing companies as members. The teamwork is apparent to the reviewer within the results presented.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer praised the future research plan and Phase II goals with timelines as excellently presented.

Reviewer 2:

This reviewer did not see where the flax fabric has any commercial surface treatment or sizing. If not, the reviewer suggested that should be explored in addition to the nanoparticle approach. If toughness is of primary interest, the reviewer believed that would suggest braids over weaves.

Reviewer 3:

This reviewer stated that Phase I has ended.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer believed that the project team demonstrated that this approach could lead to better performance than glass fibers. This work could help further enable low cost and decarbonized fibers.

Reviewer 2:

This reviewer said that the project is relevant to VTO goal for using bio derived materials.

Reviewer 3:

According to this reviewer, the team successfully demonstrated the possible expansion of natural fiber composites to structural and semi-structural applications. Sustainable composites with enhanced fatigue life and semi-structural performance address multiple R&D barriers towards sustainability goals with vehicle lightweighting.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The resources appear sufficient to this reviewer.

Reviewer 2:

The team seemed to this reviewer to have what was needed for the Phase 1 effort.

Reviewer 3:

The resources were sufficient according to this reviewer.

Presentation Number: MAT262
Presentation Title: Sustainable Automotive Composites Using Surface-Modified Cellulose Fibers
Principal Investigator: Girish Srinivas (TDA Research, Inc.)

Presenter

Girish Srinivas, TDA Research, Inc.

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

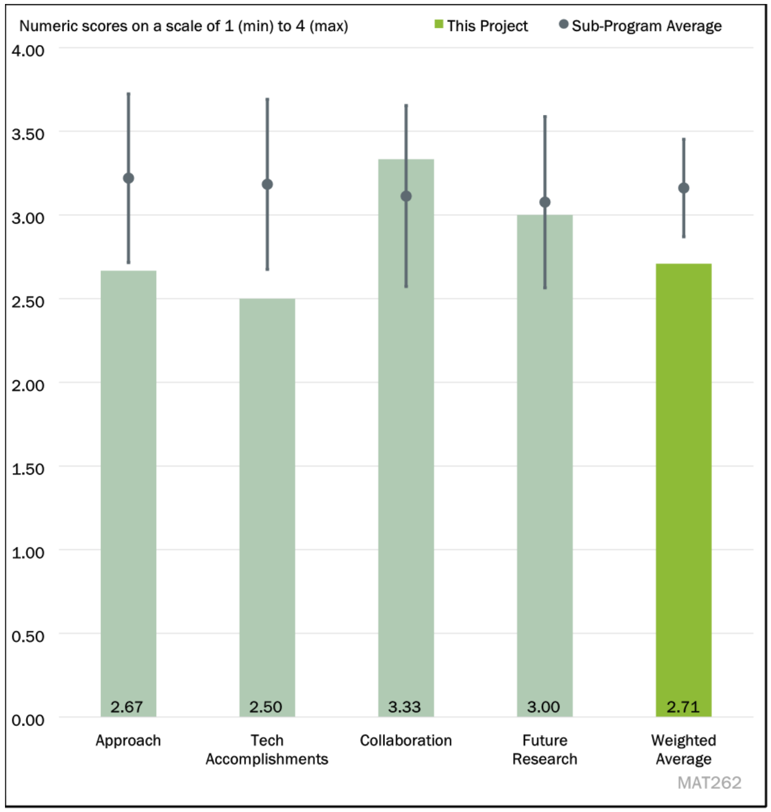

Figure 5-53 - Presentation Number: MAT262 Presentation Title: Sustainable Automotive Composites Using Surface-Modified Cellulose Fibers Principal Investigator: Girish Srinivas (TDA Research, Inc.)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The team discussed the technical barriers to lightweight a car bumper using a bio-based nylon with surface-modified cellulose fiber filler clearly enough for this reviewer. The reviewer considers this to be a good approach to reducing the CO_2 footprint of the vehicle parts by replacing polycarbonate (PC)/ABS.

Reviewer 2:

This reviewer described how the project targets to replace PC/ABS by bio-based nylon-cellulose fiber composites. While the approach has potential, the details were unclear to the reviewer. The major advantage may be the use of bio-based nylon, but the reviewer raises doubts regarding the ownership of the IP. If a simple composite of commercially available bio-based nylon with cellulose fibers (or even with some modification) is the goal, then there does not seem to the reviewer to be much innovation. Also, the reviewer was not sure about the benefit of using composites to replace non-composite thermoplastic materials. That seemed to the reviewer to be hurting eventual circularity. In addition, the detailed properties were unclear to the reviewer since the team did not show any data (e.g., various mechanical data). The team showed its estimates on density—approximately 6% reduction, leading to the lighter weight composites and tensile modulus and yield stress increase—80% of the GHG reduction through the manufacturing process. The presenter further stated that “together with a biobased lightweight core, our composite offers 52% of a vehicle’s weight reduction while showing a modest (7%) cost increase.” While these estimates may be correct, the reviewer could not evaluate them without seeing the data.

Reviewer 3:

This reviewer complained that the presentation had no data, only claims.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer commented that the team successfully accomplished producing a composite using bio-based nylon and cellulose fibers that achieved better mechanical performance than neat bio-based nylon, and it had improvements compared to PC/ABS plastics. The reviewer would have preferred that the team quantify all the mechanical properties as opposed to just stating that the properties were improved. However, the reviewer does not necessarily understand the role of TDA Research Inc. in this project. Apparently, all materials are sourced from other companies and even the modeling is performed by another team. If this project continues to Phase II, then TDA Research Inc. needs to show what the company's role is in developing, testing, or modeling the material.

Reviewer 2:

The accomplishments were unclear to this reviewer. There may be an innovation for the modified cellulose fibers or bio-based nylon, but no details were provided, according to this reviewer. LCA indicates significant reduction in carbon footprint, which is good; however, the target is PC/ABS and the reviewer is not sure that industry will adopt such substitutes. The technology has to address cost, processability, throughput, etc. While cost estimates were mentioned, many other important parameters for industrial adoption were not discussed. Considering this is SBIR, the reviewer believes that the team needs to clearly define the performance/cost target to really make this a commercially viable product. Unfortunately, the presentation was too generic, and the reviewer did not find it possible to evaluate how good or how limited the value of this technology will be.

Reviewer 3:

This reviewer complained that the presentation has no data, only claims.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

TDA Research Inc. made good use of existing cellulose and bio-nylon.

Reviewer 2:

This reviewer applauded the team for assembling a great collaboration with many different entities, including a biobased nylon supplier, a core material supplier, a computational engineering company, University of Colorado at Denver for LCA, and the Larta Institute for a business model and marketing strategy. However, TDA Research Inc. needs to specify the tasks that they are performing within this project.

Reviewer 3:

This reviewer noted that the team listed the partners and some of collaborations. Their roles are satisfactory; however, it is unclear to the reviewer how this technology can be commercialized by strategic collaboration.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The future plan seemed satisfactory to this reviewer, but it was not clear to the reviewer why and how the future work will connect to commercially-viable products. As a research activity, the research made sense but it was unclear how viable the plan will be toward commercialization.

Reviewer 2:

This reviewer commented that the presenter stated that the project has ended.

Reviewer 3:

This reviewer believed that the proposed research is satisfactory but future test data should be included in a report.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer confirmed that the project is relevant. The approach is clearly addressing one of the paths for low-carbon and low-energy composites. But, as the reviewer commented previously, making composites to replace non-composites may not work for industry.

Reviewer 2:

The project is very relevant to the VTO Materials subprogram objectives of lightweighting a vehicle while also reducing CO_2 footprint of the materials, according to this reviewer.

Reviewer 3:

This reviewer said that material properties and CO_2 reduction claims support VTO goals.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer believed the team has the needed resources to conduct the research but the reviewer could not ascertain this with certainty because the detail was not provided, which made the resources needed unclear.

Reviewer 2:

While this reviewer said that the project has ended, the reviewer believed that the resources were sufficient to deliver on the targeted milestones.

Reviewer 3:

This reviewer found good project leverage using existing biomaterials.

Presentation Number: MAT263
Presentation Title: Green Polybenzoxazine/Natural Fiber Composites for Transportation
Principal Investigator: Christopher Scott (Material Answers, LLC)

Presenter

Christopher Scott, Material Answers, LLC

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

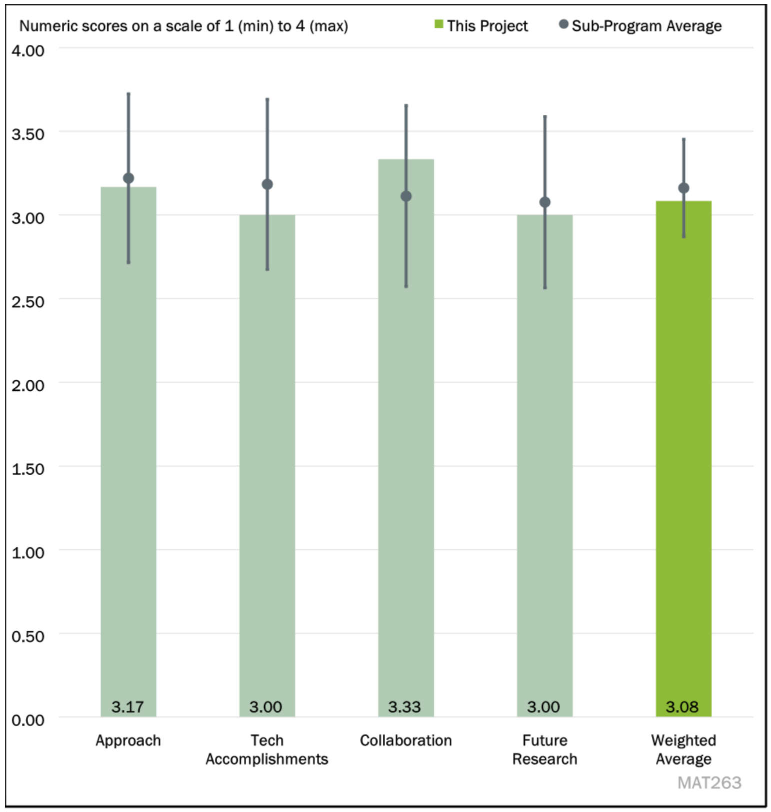

Figure 5-54 - Presentation Number: MAT263 Presentation Title: Green Polybenzoxazine/Natural Fiber Composites for Transportation Principal Investigator: Christopher Scott (Material Answers, LLC)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer praised the team for having a great approach to create benzoxazine resin using bio-based chemicals. The added vitrimer behavior adds to the novelty by enabling recycling of the composites. The composite had added natural flax fiber to make it even more environmentally friendly. The technical barriers were clearly addressed, and the challenges were met in a timely manner.

Reviewer 2:

This reviewer related that the proposed research plans to develop a flax fiber-reinforced sustainable polybenzoxazine resin composite. The team invented and characterized a novel bio-based benzoxazine resin, although resin characteristics and consistency in properties have not been presented. The composite exhibits recycling via transesterification. The energy demand for these composites are estimated to be lower than that of the Al, glass-fiber composites, or CFRCs. The properties of the resin system and feedstocks were not discussed (likely proprietary information), according to the reviewer.

Reviewer 3:

This reviewer commented that, while the approach to use bio-based polymer (polybenzoxazine), flax fibers, and addition of dynamic functional groups to make vitrimers is good, the reviewer is unclear as to the viability of the approach. The reviewer also questions who owns the IP, specifically if it is Case Western Reserve University. The major problem seems that the composite's mechanical property (shown in the future work slide) seems too low to be viable. While polybenzoxazine provides an advantage of flame retardancy, the reviewer is unclear on how this specific bio-based polybenzoxazine with flax fibers can provide sufficient mechanical properties for target application.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer considered that the team accomplished all milestones that were mentioned. The team produced 450 g of the material, performed appropriate characterization, and fabricated composites within the timeframe of the project. The project showed the ability to reshape the composite as a recycling demonstration; however, the reviewer questions whether the resin and fibers can be recovered separately at the end of life. The reviewer would like to see that the fiber and resin can be fully recycled. Simply reshaping a composite does not necessarily solve the recycling issue. Also, a cost estimate would be good to have for this resin system to gauge the commercial feasibility.

Reviewer 2:

According to this reviewer, the project team, using Professor Ishida's laboratory, were certainly able to generate this specific polybenzoxazine/flax fiber composites so the plan may be accomplished; however, the achieved performance will not replace structural composites. The reviewer was unclear as to how the team will improve the mechanical property as shown in the future plan target. Making vitrimer is good to provide processability of thermoset property of polybenzoxazine; however, the team seems to use ester-based (catalyst) dynamic functional groups. The catalyst will provide malleability for manufacturing, but long-term stability may be a challenge. When there is need to repair or reprocess, this approach may not work well. Considering all of the potential hurdles, the team should have advanced much further during Phase I. If the material achieved much higher mechanical properties, then the remaining hurdle is lower. But that major hurdle is not addressed, which the reviewer doubted can be addressed quickly even in Phase II. The reviewer would have preferred to have seen more data. The reviewer admitted to possibly missing some of the potentials, but little discussion was given retarding the attributes and the mechanical performance, etc., if the claims are true.

Reviewer 3: .

This reviewer lamented that few data were presented, making it very difficult to estimate the progress. The dynamic mechanical analysis Tg was 116^{o}C but after two hours of curing, the Tg increased to 149^{o}C. The reviewer is not clear on how far below Tg the material would undergo transesterification reaction for the proposed recycling. Also, the slides presented to the reviewers showed a technical data sheet of the composite. The reviewer is unsure of why much of the characterization data and compositions are not mentioned. If the composite is already developed, then there should be a commercialization plan. Developmental R&D may not be needed, according to the reviewer.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

This reviewer applauded the collaboration with Case Western Reserve University (Professor Ishida) as excellent. For polybenzoxazine development, Professor Ishida's group is the group to work with. But the reviewer asks, who then owns the IP?

Reviewer 2:

This reviewer believed that there was an excellent collaboration with Professor Ishida at Case Western Reserve University, who is an expert in bio-based benzoxazine resin. To further improve the collaborations in the future, bringing in a tier 1 supplier or OEM would really benefit the project to prove its application feasibility.

Reviewer 3:

This reviewer pointed out that Case Western Reserve University has developed the resin. (The reviewer is not sure who owns the IP). But the reviewer noted that the collaboration lacks partnership with a tier 1 part manufacturer.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer noted that the presenter stated that the project has ended. The proposed future research directions are clearly defined if this project gets funded for Phase II, according to the reviewer.

Reviewer 2:

This reviewer felt that, if satisfactory properties have already been achieved, the proposed future work is reasonable. However, the team aims to double or triple mechanical performance in future work, which is not realistic. If the TEA has a clear plan to meet the performance, it should have been described.

Reviewer 3:

This reviewer commented that the team has already developed a product (see product technical data sheets) that meets property needs for vehicle composites. The future research plan does not need resin and composite development tasks as those are already finalized. Phase II should focus on Thrust 3 and Thrust 4.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer found that the project supports the VTO Materials subprogram objective of vehicle lightweighting and reducing CO_2 footprint by utilizing bio-based materials.

Reviewer 2:

This reviewer noted that sustainable composites can help meet VTO Materials subprogram goals for sustainability along with vehicle component lightweighting.

Reviewer 3:

This reviewer confirmed that pursuing bio-based resins with natural fibers is a good direction for achieving low-carbon and low-embodied energy materials but the performance of these resins is not meeting the requirements of structural composites. If the team could identify a different target with marketable vehicle parts (by meeting cost/sustainability advantage etc.), the current performance may have a case to further pursue.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The project has ended, but it seemed to the reviewer that the resources were sufficient to deliver on the targeted milestones.

Reviewer 2:

This reviewer stated that the resources are sufficient.

Reviewer 3:

The resources seemed sufficient to this reviewer; especially, the participation by Case Western definitely helps to develop promising resins. Maybe a single goal to achieve the performance was too aggressive. Since this is a SBIR, the team should have accomplished reasonably high performance even before starting the SBIR project.

Presentation Number: MAT264
Presentation Title: Green Composites for Future Vehicles, Vitrimer Matrix + Natural and Recycled Fiber Composite Materials for High Performance, Repairable, Recyclable, and Bio-sourced Automotive Components
Principal Investigator: Philip Taynton (Mallinda, Inc.)

Presenter

Philip Taynton, Mallinda, Inc.

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

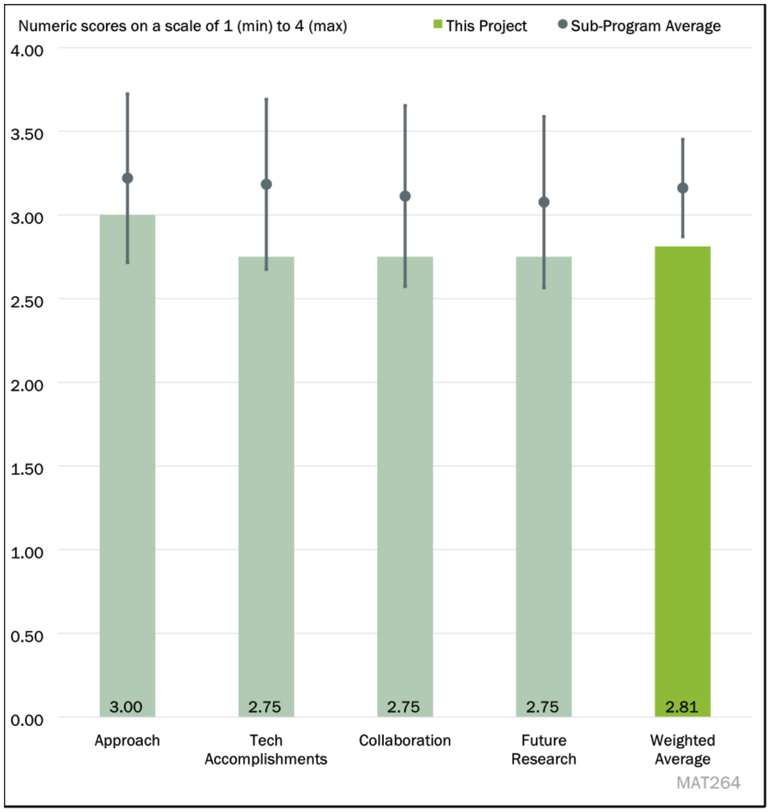

Figure 5-55 - Presentation Number: MAT264 Presentation Title: Green Composites for Future Vehicles, Vitrimer Matrix + Natural and Recycled Fiber Composite Materials for High Performance, Repairable, Recyclable, and Bio-sourced Automotive Components Principal Investigator: Philip Taynton (Mallinda, Inc.)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer described how the project pursued flax fiber vitrimer composites. Considering the high GHG and energy input of CF production, exploring natural fiber-based composites is good. The team is utilizing its Vitrimax to produce the composites, in which the vitrimer matrix (Vitrimax) will provide malleability and recyclability with enhanced robustness due to its crosslinked network. Considering the team’s success with Vitrimax, looking into flax fiber composites makes sense, although it was not perfectly clear to the reviewer what vehicle parts are suitable for this specific composites. The reviewer notes that the achieved mechanical performance is much lower than that of CFRPs.

Reviewer 2:

The approach did not appear to this reviewer to be compatible with automotive manufacturing rates since the vitrimer polymerization process is quite slow. The work should detail how this technology can be applied to high-rate manufacturing.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer related that the project successfully fabricated Vitrimax/flax fiber composites and showed the path for mechanical and chemical recycling. As the team indicated, there is a need to further tailor the various parameters such as viscosity, as well as chemical recycling details. As a Phase I effort, the project has accomplished what was needed, considering that the team already has a knowledge of vitrimer composites. Since the mechanical performance of this composite is much lower than those of CF and glass fiber composites, the team needs to clarify what application (e.g., specific vehicle parts) will be suitable for the use of this composite. If the mechanical properties, as well as cost performance, do not meet any of the vehicle parts, this project should simply end as having accomplished some exploratory research.

Reviewer 2:

This reviewer considered that the team has made progress towards its Phase I goals; however, the performance of the composites is quite poor and there was not a discussion into the methods to improve performance.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

This reviewer pointed out that the team collaborated with the University of Southern California (USC) for various composite characterizations. USC has strong expertise on composite research, so this collaboration is mutually beneficial.

Reviewer 2:

This reviewer believes that the team would benefit from an OEM partner to show commercialization potential.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer pointed out that the team proposed to pursue following tasks: (1) optimization of composite material, (2) development of room temperature infusion resin, (3) accelerated ageing and fatigue studies, recycling process optimization, and (4) prepreg optimization. In general, the plan is good, and the team seems to be aware of the technical challenges that need to be addressed. But, again, the team should clearly identify what kind of vehicle parts that the material intends to replace. If there is a large potential market, then this flax/Vitrimax composite research makes sense.

Reviewer 2:

The future plans are vague, according to this reviewer.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The project is highly relevant in this reviewer’s thinking. Vitrimers represents next generation resins for composites which can address various sustainability challenges. This project further expands to the use of bio-based fibers which could potentially address the challenges of high carbon and energy footprint by CFs or many other fibers.

Reviewer 2:

This reviewer believes that lightweighting is important for future vehicles.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer affirmed that both Mallinda and USC have enough resources to conduct the proposed research.

Reviewer 2:

This reviewer stated that the team completed its objectives.

Acronyms and Abbreviations – MAT

Abbreviation	Definition
3D	Three-dimensional
G3 5M	G3 5M steel alloy
A206	A206 composite matrix
AA7075	AA7075 aluminum alloy
ABS	Acrylonitrile butadiene styrene
ACMZ	Aluminum-copper-manganese-zirconium
AI	Artificial intelligence
Al	Aluminum
AM	Additive manufacturing
AM20	AM20 magnesium cast alloy
AM50	AM50 magnesium cast alloy
AM60B	AM60B magnesium cast alloy
AMR	Annual Merit Review
ANL	Argonne National Laboratory
ASTM	ASTM International, formerly known as American Society of Testing and Materials
AZ91D	AZ91D magnesium cast alloy
BAAM	Big area additive manufacturing
$BaTiO_3$	Barium titanate
BFM	Bast fiber material
BOTTLE	Bio-Optimized Technologies to keep Thermoplastics out of Landfills and the Environment
CAE	Computer aided engineering
CCF	Continuous carbon fiber
CF	Carbon fiber
CFRP	Carbon fiber reinforced polymer
CFTF	Carbon Fiber Technology Facility
CNG	Compressed natural gas
CNT	Carbon nanotube
CO_2	Carbon dioxide
COMSOL	COMSOL Multiphysics ® modeling software

Abbreviation	Definition
COOH	Carboxyl
COVID	Coronavirus disease (COVID-19), infectious disease caused by the SARS-CoV-2 virus
CRADA	Cooperative Research and Development Agreement
DLP	Digital light processing
DOE	U.S. Department of Energy
EERE	Energy Efficiency and Renewable Energy
EMI	Electromagnetic interference
EV	Electric vehicle
FCA	Fiat Chrysler Automobiles
FSP	Friction stir processing
GHG	Greenhouse gas
GM	General Motors
H11	H11 tool steel alloy
H_2O	Water
HPM	High-performance modeling
HTC	High temperature carbonization
HVR	High-velocity riveting
ICME	Integrated computation materials engineering
ID	Identification
IP	Intellectual property
ISO	International Standards Organization
L12	Phase of steel crystalline structure
LCA	Life cycle analysis
LLC	Limited liability corporation
LLNL	Lawrence Livermore National Laboratory
LMCP	Lightweight Metals Core Program
MAT	VTO Materials subprogram
Mg	Magnesium
ML	Machine learning
MMC	Metal matrix composites

Abbreviation	Definition
MoS_2	Molybdenum disulfide
MR	Molecular Rebar®
MRL	Manufacturing readiness level
$NiFe_2O_4$	Nickel ferrite
NMVC-R2	Nano- and micro-filler reinforced vitrimer composites using recycled milled carbon fibers
NREL	National Renewable Energy Laboratory
OEM	Original equipment manufacturer(s)
OH	Hydroxyl
ORNL	Oak Ridge National Laboratory
PAEK	Polyaryletherketone
PAN	Polyacrylonitrile
PC	Polycarbonate
PE	Polyethylene
PET	Polyethylene terephthalate
PLA	Polylactic acid
PMCP	Powertrain Materials Core Program
PNNL	Pacific Northwest National Laboratory
PP	Polypropylene
PUSP	Power ultrasonic-based surface processing
PVDF	Polyvinylidene fluoride
R&D	Research and development
RDD&D	Research, development, deployment and demonstration
SBIR	Small Business Innovation Research
SDF	Sudamericana de Fibras (company name)
ShAPE	Shear assisted processing and extrusion
SLIC	Sustainable Lightweight Intelligent Composites
T4	T4 level of steel temper
T6	T6 level of steel temper
T76	T76 level of steel temper
TEA	Techno-economic analysis

Abbreviation	Definition
Tg	Glass transition temperature
TiB_2	Titanium diboride
TRL	Technology readiness level
UCC	Ultra conductive copper
UHMWPE	Ultra-high molecular weight polyethylene
UNT	University of North Texas
URJ	Ultrasonic rivet joining
USA	United States of America
USC	University of Southern California
USW	Ultrasonic welding
VTO	Vehicle Technologies Office

6. Technology Integration

The Vehicle Technologies Office (VTO) supports research, development, demonstration, and deployment (RDD&D) of new, efficient, and clean mobility options that are affordable for all Americans. The office's investments leverage the unique capabilities and world-class expertise of the national laboratory system to develop new innovations in vehicle technologies, including: advanced battery technologies; advanced materials for lighter-weight vehicle structures and better powertrains; energy-efficient mobility technologies and systems (including automated and connected vehicles as well innovations in connected infrastructure for significant systems-level energy efficiency improvement); innovative powertrains to reduce greenhouse gas (GHG) and criteria emissions from hard to decarbonize off-road, maritime, rail, and aviation sectors; and technology integration that helps demonstrate and deploy new technology at the community level. In coordination with the other offices across the Office of Energy Efficiency and Renewable Energy (EERE) and the U.S. Department of Energy (DOE), VTO advances technologies that assure affordable, reliable mobility solutions for people and goods across all economic and social groups; enable and support competitiveness for industry and the economy/workforce; and address local air quality and use of water, land, and domestic resources.

The Technology Integration (TI) subprogram supports the decarbonization of the transportation sector through various initiatives that accelerate the adoption of electric vehicles (EVs) and charging infrastructure. The program covers a broad technology portfolio that includes alternative fuels (e.g., advanced biofuels, electricity, hydrogen, renewable natural gas) and energy efficient mobility systems. The successful deployment of these technologies can support the decarbonization of the transportation sector, strengthen national security through fuel diversity and the use of domestic fuel sources, reduce transportation energy costs for businesses and consumers, address the needs of underserved communities, and support energy resiliency with affordable alternatives to conventional fuels that may face unusually high demand in emergency situations.

At the national level, TI offers technical assistance, information resources, online training, and an array of data and analysis tools. At the local level, the subprogram administers Clean Cites and Communities, a DOE partnership to advance clean transportation nationwide. This federal partnership includes more than 75 DOE-designated Clean Cities and Communities coalitions that leverage DOE resources to create networks of stakeholders and provide hands-on technical assistance to communities and fleets. Clean Cities and Communities serves as a backbone for partnering with cities, towns, and rural areas across the country on clean transportation technology. The Heavy-Duty Truck Fueling Corridor activity funds an Integrated Heavy-Duty Zero Emission Vehicle (ZEV) Fueling and Connected Grid project to demonstrate integrated clean corridor solutions, connecting truck depots, ports, highways, and end users, providing electric vehicle charging infrastructure and freight solutions. The Clean Energy to Communities activity provides unbiased expertise, tools, and resources to cities and communities as they set clean energy, equitable transportation, and climate resilience goals. The Technical Assistance and Demonstration activity supports projects that provide information, insight, online tools, and technology assistance to cities, states, and regions working to implement clean transportation solutions and energy efficient mobility technologies and systems. The Data Collection and Dissemination activity collects and provides objective, unbiased data, information, and real-world lessons learned to fleets and local decision makers, while also funding the Alternative Fuels Data Center and the annual Fuel Economy Guide. Finally, TI supports STEM and workforce development through its EcoCar Mobility Challenge and Battery Workforce Challenge collegiate competitions, advancing powertrain systems, connected and automated vehicle technology and EV battery packaging to improve efficiency, safety, and consumer appeal.

Project Feedback

In this merit review activity, each reviewer was asked to respond to a series of questions, involving multiple-choice responses, expository responses where text comments were requested, and numeric score responses (on a scale of 1.0 to 4.0). In the pages that follow, the reviewer responses to each question for each project will be summarized: the multiple choice and numeric score questions will be presented in graph form for each project, and the expository text responses will be summarized in paragraph form for each question. A table presenting the average numeric score for each question for each project is presented below.

Table 6-1 – Project Feedback

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Objectives	Approach	Accomplishments	Collaboration	Energy Equity and Environmental Justice (EEEJ)	Weighted Average
TI093	EVSE Innovation: Streetlight Charging in City Right-Of-Way	Miriam Bouallegue (Metropolitan Energy Center)	6-6	3.38	3.25	3.50	3.13	3.13	3.35
TI126	Twin Cities Electric Vehicle Community Mobility Network	Lisa Thurstin (American Lung Association)	6-10	3.88	3.75	3.25	3.50	3.25	3.50
TI127	The Mid-Atlantic Electrification Partnership: An Electrification Ecosystem of Intermodal Leadership and Intercity Travel	Alleyn Harned (Virginia Clean Cities)	6-15	3.50	3.75	3.25	3.50	3.25	3.43
TI128	Western Smart Regional Electric Vehicles Adoption and Infrastructure at Scale	James Campbell (PacifiCorp)	6-18	3.50	3.50	3.33	3.50	3.33	3.42
TI129	Helping America's Rural Counties Transition to Cleaner Fuels and Vehicles	Ken Brown (Transportation Energy Partners)	6-22	3.75	3.50	3.13	3.25	3.50	3.38
TI130	VoICE-MR: Vocation Integrated Cost Estimation for Maintenance and Repair of Alternative Fuel Vehicles (AFV)	Arvind Thiruvengadam (West Virginia University)	6-26	3.50	3.63	3.25	3.00	3.00	3.33

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Objectives	Approach	Accomplishments	Collaboration	Energy Equity and Environmental Justice (EEEJ)	Weighted Average
TI131	DRIVE (Developing Replicable, Innovative Variants for Engagement) for EVs in the USA	Jonathan Overly (East Tennessee Clean Fuels Coalition)	6-30	3.67	3.50	3.67	3.50	2.67	3.52
TI132	NFPA Spurs the Safe Adoption of Electric Vehicles through Education and Outreach	Andrew Klock (National Fire Protection Association)	6-33	3.38	3.63	3.50	3.75	2.63	3.44
TI134	Delivering Clean Air in Denver: Propane Truck and Infrastructure in Mail Delivery Application	Bonnie Trowbridge (Drive Clean Colorado)	6-37	3.30	3.20	2.60	2.70	2.90	2.90
TI135	Advancing Climate and Innovation Goals of Memphis and Shelby County: Electrification of Key Fleet Vehicles to Capture Cost Savings and Climate Benefits	Leigh Huffman (Shelby County)	6-41	3.00	3.13	3.13	3.50	2.75	3.10
TI136	Zero Emission Freight Future	Tim Cho (Clean Fuels Ohio)	6-44	3.70	3.50	3.20	3.60	2.70	3.35
TI137	Cold-Weather Operation, Observation and Learning Electric Vehicles	Lisa Thurstin (American Lung Association)	6-48	3.70	3.20	2.70	3.00	3.40	3.10
TI138	Demonstrating Electric Shuttles for the New Orleans Region	Jordan Stewart (Tulane University)	6-52	3.13	3.13	2.38	2.75	2.88	2.76
TI139	Pilot Heavy-Duty Electric Vehicle (EV) Deployment for Municipal Solid Waste Collection	Kelli Toth (Municipality of Anchorage)	6-55	3.63	3.25	2.63	2.88	2.75	2.99

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Objectives	Approach	Accomplishments	Collaboration	Energy Equity and Environmental Justice (EEEJ)	Weighted Average
TI140	St. Louis Vehicle Electrification Rides for Seniors (SILVERS)	Connor Herman (Forth Mobility)	6-58	3.63	3.63	3.75	3.88	3.88	3.73
TI141	Integrated Fuel Cell Electric Powertrain Demonstration	Patrick Kaufman (Cummins)	6-62	3.13	3.13	2.88	3.00	3.25	3.03
TI142	Field Demonstration of a Near-Zero, Tier 5 Compliant, Natural Gas Hybrid Line-Haul Locomotive	Ted Barnes (Gas Technology Institute)	6-66	3.50	3.50	3.13	3.50	3.13	3.31
TI143	Medium-Duty Electric Truck (Etruck): Pilot Electrified Fleets in Urban and Regional Applications	Junmin Wang (University of Texas-Austin)	6-69	3.63	3.38	3.50	3.63	2.88	3.45
TI144	Creating the NFPA Distributed Energy Resources Safety Training (DERST) Program	Andrew Klock (National Fire Protection Association)	6-73	3.33	3.50	3.50	3.67	2.67	3.40
TI145	Electric Vehicle Market Stimulation in Divested Economies	Miriam Bouallegue (Metropolitan Energy Center)	6-75	3.50	3.50	3.00	3.25	3.75	3.30
TI146	Rural Reimagined: Building an EV Ecosystem and Green Economy for Transforming Lives in Economically Distressed Appalachia	Pingen Chen (Tennessee Tech)	6-78	3.63	3.88	3.50	3.75	3.50	3.63
TI147	Affordable Mobility Platform	Connor Herman (Forth Mobility)	6-82	3.67	3.50	3.17	3.50	3.50	3.40
TI148	Upper Midwest Inter-Tribal Electric Vehicle (EV) Charging Community Network	Robert Blake (Native Sun Community Power Development)	6-85	3.63	3.88	3.63	3.88	3.88	3.73

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Objectives	Approach	Accomplishments	Collaboration	Energy Equity and Environmental Justice (EEEJ)	Weighted Average
TI149	Equitable Mobility Powering Opportunities for Workplace Electrification Readiness (EMPOWER)	Michael Graham (Western Washington Clean Cities)	6-89	3.60	3.50	3.60	3.80	3.70	3.61
TI150	Charge To Work USA	Jason Zimbler (CALSTART)	6-93	3.50	3.50	3.10	3.60	3.40	3.34
TI151	Leadership of Employers for Electrification Program	Steffani Cuff (Forth Mobility)	6-97	3.50	3.50	3.50	3.70	3.60	3.53
TI152	Project Sila: An Arctic CNG Pilot Test Program	Keith Patterson (ASRC Energy Services)	6-101	3.50	3.50	3.40	3.60	3.50	3.47
Overall Average				**3.51**	**3.47**	**3.23**	**3.42**	**3.21**	**3.35**

Presentation Number: TI093
Presentation Title: EVSE Innovation: Streetlight Charging in City Right-Of-Way
Principal Investigator: Miriam Bouallegue (Metropolitan Energy Center)

Presenter

Miriam Bouallegue, Metropolitan Energy Center

Reviewer Sample Size

A total of four reviewers evaluated this project.

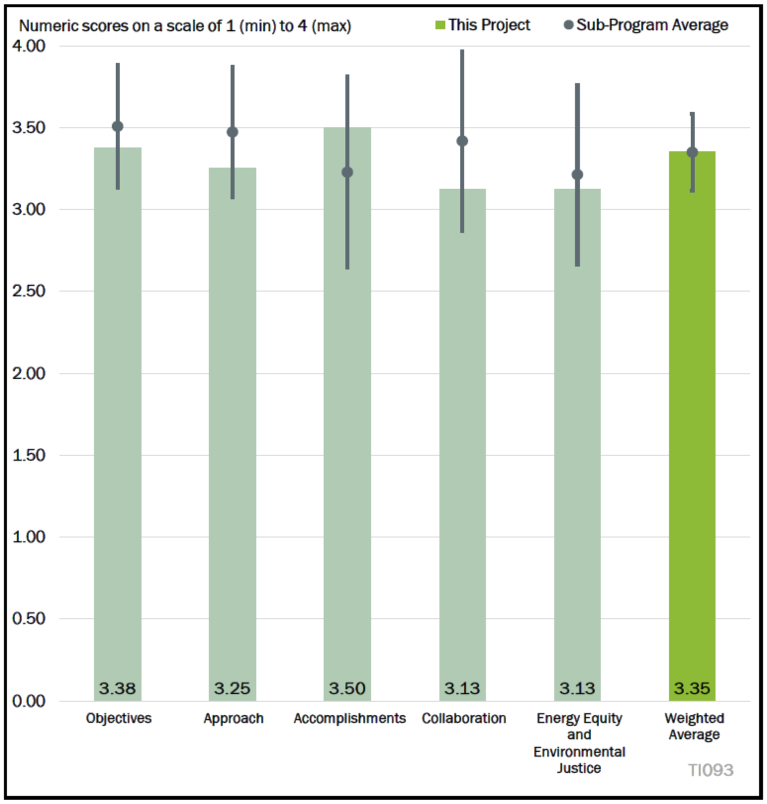

Figure 6-1 - Presentation Number: TI093 Presentation Title: EVSE Innovation: Streetlight Charging in City Right-Of-Way Principal Investigator: Miriam Bouallegue (Metropolitan Energy Center)

Question 1: Please provide comments on this project's degree of support for the overall Technology Integration (TI) objectives of improving fuel diversity, increasing local resiliency, and reducing greenhouse gas emissions through increasing alternative fuel use and transportation efficiency.

Reviewer 1:

The reviewer stated that the project very directly supports these objectives by providing increased access to EV fuelin g in a way that promotes resilience and equity. The reviewer added that more ubiquitous adoption of EVs will require novel, convenient solutions for charging, like what is being done here.

Reviewer 2:

The reviewer opined that the goal of using light poles owned by the city is a better approach than using telephone poles owned by the utilities and added that it is an excellent approach.

Reviewer 3:

The reviewer noted that this project provides excellent support for TI objectives by increasing access to alternative fuel use via the deployment of EV charging. The reviewer added that the use of existing infrastructure (streetlights in the right-of-way) additionally allows for greater affordability for local governments to deploy a substantial number of EV charging stations.

Reviewer 4:

The reviewer commented that the project objectives support improving fuel diversity, increasing local resiliency, and reducing GHG emissions in Kansas City. The reviewer added that the use of streetlight charging appears to be an efficient urban charging solution that can be expanded to other cities through a well thought-out, replicable process.

Question 2: Please comment on this project's approach for integrating advanced transportation technologies and practices to solve real-world challenges.

Reviewer 1:

The reviewer commented that this demonstration project will help advance the studied technology by implementing it in a real-world setting. The reviewer noted that successful case studies are particularly useful for other entities as they consider deploying this technology, and lessons learned from this effort will help those entities avoid pitfalls and employ best practices.

Reviewer 2:

The reviewer stated that while they have identified points of interest to locate electric vehicle supply equipment (EVSE) they should identify multi-family housing (MFH) such as three family units with no driveways or garages to locate EVSE on the street.

Reviewer 3:

The reviewer commented that the approach to determining where to install charging infrastructure is excellent, both in its teaming arrangement and in the market demand modeling approach. The reviewer noted that the project team is comprised of a number of industry stakeholders that are key to the success of deploying EV charging infrastructure in the right of way while also prioritizing increasing access to charging for MFH residents. The reviewer added that in addition to working with local governments to overcome barriers associated with utilizing streetlight infrastructure as a source for EVSE, the project has conducted ample community engagement throughout, including hosting public listening sessions, conducting outreach with local media, incorporating feedback from local residents during construction, and creating a plan for building awareness of the new chargers. The reviewer observed that, related to the community engagement, the project built a market demand model to look at a number of factors that inform EV adoption and access to charging and then used the data in the model to inform site selection, with an added prioritization for underserved communities.

Reviewer 4:

The reviewer noted that this project uses a straightforward approach to accomplish its objectives, specifically using a streetlight charging application, and it provides steps and milestones. The reviewer was interested to see further details on EV charging site selection criteria, benefits of streetlight technology, and community outreach results. The reviewer observed that other projects seemed to incorporate a much more regional approach and noted that it may be important for the gathered information to be applied in other parts of the Kansas City region. The reviewer expressed an interest in seeing more information on community engagement, city feasibility, future plans, how this opportunity will directly impact communities, and how to plan for other municipalities to use this project to inform their own streetlight charging initiatives.

Question 3: Please comment on the project's progress and significant accomplishments to date.

Reviewer 1:

The reviewer stated that the project has accomplished much of the challenging groundwork necessary to complete prior to implementation, like site surveys and hardware development.

Reviewer 2:

The reviewer noted that they project team seems to be on target to move to the next steps in this grant and added that the fact they have identified the technology is important so equipment can be ordered. The reviewer also noted that permits have been acquired, which is important.

Reviewer 3:

The reviewer commented that the project has achieved a majority of its key milestones, building upon previous milestones and lessons learned through the market demand modeling. The reviewer further noted that, throughout the process, the project has been able to focus on its overall objective to provide a more affordable solution for building an EV charging network while utilizing existing streetlight infrastructure.

Reviewer 4:

The reviewer observed that 60% of this project is completed, with one year left in the timeline to complete the project, and there appears to be good progress made in selecting EVSE technology and urban charging sites. The reviewer noted that there is further work required to finish installing EVSE, activate data monitoring, and complete project analysis and reporting. The reviewer stated that the market demand and underserved models are promising deliverables for this project. The reviewer is interested in more information regarding how communities will be involved in this project and how these deliverables can inform other urban areas/cities.

Question 4: Please comment on the level of collaboration within the project team and the degree to which the project team has identified and leveraged the proper connections to achieve its project goals.

Reviewer 1:

The reviewer noted that the project team has collaborated with a diverse set of partners including local municipalities, utilities, universities, advocacy organizations, and national laboratories.

Reviewer 2:

The reviewer stated that while the National Renewable Energy Laboratory (NREL) is involved, it would be better to have a Clean Cities coalition involved.

Reviewer 3:

The reviewer commented that the project team is appropriate for the scale and scope of this project. The reviewer added that this project has the potential to provide takeaways and replicable solutions for other cities and communities across the country, and the data-driven approach which relies on public-private partnerships is an excellent foundation towards that goal.

Reviewer 4:

The reviewer stated that the list of partners provided appears to be relatively diverse but noted that there is not much detail provided on how these partners will be involved with collaboration and coordination.

Question 5: Please provide comment on the contribution of this project to energy equity and environmental justice by ensuring the project benefits underserved and overburdened communities and does not cause increased burdens to these communities.

Reviewer 1:

The reviewer expressed the view that this project stands to provide a tangible benefit to disadvantaged communities (DACs) by creating accessible and low-cost charging solutions that are practical for EV owners that cannot charge at home. The reviewer added that this is an essential feature of an equitable charging network, as most EV owners charge at home, but doing so is often not an option for those who do not live in detached single-family homes.

Reviewer 2:

The reviewer stated that while the project team points out some environmental justice (EJ) communities, there were no specific goals for how many EVSEs would be located in these targeted areas in the communities.

Reviewer 3:

The reviewer noted that this project does have a focus on underserved communities as key voices in the determination of where to site charging, and that considerations about current barriers to charging/EV access have been incorporated into the market modeling. The reviewer stated that this work has centered around MFH properties, but the presentation did not speak to EJ community engagement in this work although there are key partners as part of the project team.

Reviewer 4:

The reviewer commented that this project has the potential to benefit underserved and overburdened urban communities and added that the communities' needs could be central to the EVSE siting decision-making process. The reviewer opined that further discussion regarding additional feasibility information to guarantee streetlight chargers are placed in areas that provide service to urban communities and bring economic opportunity, without inhibiting local residents' ability to use parking spaces, may be needed.

Presentation Number: TI126
Presentation Title: Twin Cities Electric Vehicle Community Mobility Network
Principal Investigator: Lisa Thurstin (American Lung Association)

Presenter

Lisa Thurstin, American Lung Association

Reviewer Sample Size

A total of four reviewers evaluated this project.

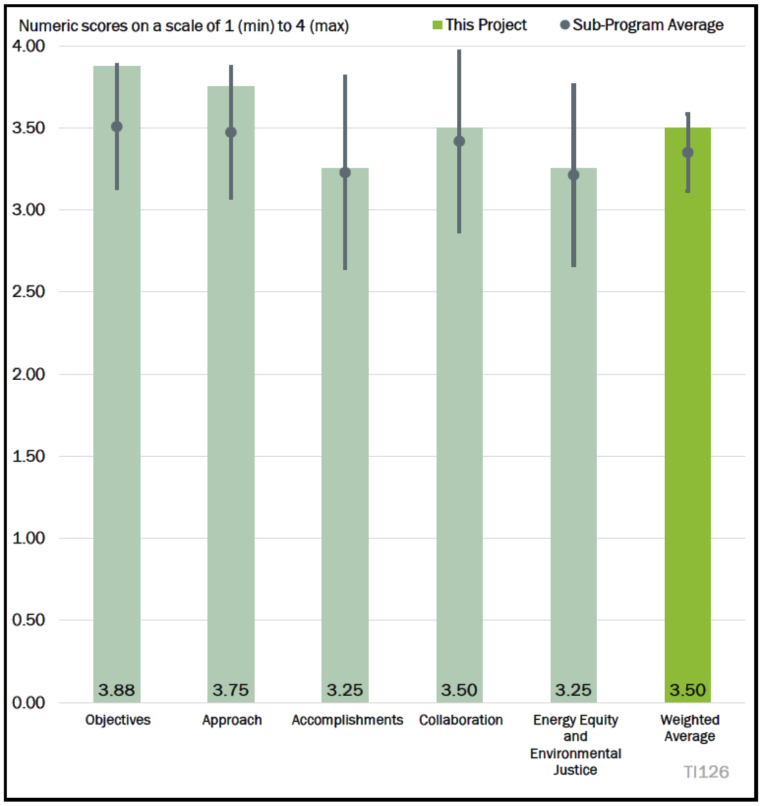

Figure 6-2 - Presentation Number: TI126 Presentation Title: Twin Cities Electric Vehicle Community Mobility Network Principal Investigator: Lisa Thurstin (American Lung Association)

Question 1: Please provide comments on this project's degree of support for the overall Technology Integration (TI) objectives of improving fuel diversity, increasing local resiliency, and reducing greenhouse gas emissions through increasing alternative fuel use and transportation efficiency.

Reviewer 1:

The reviewer stated that this project's objectives are supporting TI objectives in a way that is specific to the region while also providing an example that can be replicated in other regions. The reviewer noted that the project objectives are to reduce GHG emissions and improve fuel diversity by increasing the number of EVs and charging stations in the geographic region, especially for communities that have more barriers to these technologies. The reviewer added that the objective of creating a community-focused mobility network specifically helps reduce GHG emissions and increases local resiliency.

Reviewer 2:

The reviewer stated that the team presented a compelling project, describing the opportunities and the obstacles they faced, and added that the overarching impacts (increased EV adoption and awareness, increased awareness of vehicle charging infrastructure and documented best practices) were well conveyed. The reviewer noted that the effort is squarely within the overall TI objectives, specifically GHG emissions.

Reviewer 3:

The reviewer commented that the combination of EVs and EV infrastructure, outreach, partnerships, and intended benefits of this project support the overall TI objectives in these communities. The reviewer stated that emphasizing MFH properties is an important element in promoting and supporting fuel diversity and transportation efficiency, and that the EV car share offers another cleaner mobility option for community members and supports a more resilient local transportation system. The reviewer indicated that it would be great to understand how local community engagement efforts contribute to the co-design of project elements, as this kind of activity supports resiliency. The reviewer observed an overall excellent degree of support for objectives.

Reviewer 4:

The reviewer stated that the project is addressing the TI objectives of improving fuel diversity by creating a community focused EV charging and shared EV network, facilitating electric mobility access for those without private EVs. The reviewer commented that the Twin Cities project is decreasing GHG emissions from tailpipes by having deployed over 100 EVs in the car sharing programs and EVSE at five MFH properties, and the principal investigators documented and presented over 10,000 monthly trips in March 2023.

Question 2: Please comment on this project’s approach for integrating advanced transportation technologies and practices to solve real-world challenges.

Reviewer 1:

The reviewer commented that the project model and approach have built on best practices in EV car sharing and show how to successfully implement an EV car sharing project that is iterative, responsive to community feedback, and increases participation in the program. The reviewer added that the project approach also has strong community engagement which allows for community members to be more aware of the program while using community engagement to improve the project.

Reviewer 2:

The reviewer stated that the approach was clearly communicated and showed efforts to solve real-world problems in an area of the country that faces extreme cold. The reviewer observed that the obstacles the team faced were real—supply chain issues, vehicle recalls, launching in MFH areas, taking a community focused approach—and are all issues that take time and sophistication to overcome.

Reviewer 3:

The reviewer stated that the combination of infrastructure, outreach, partnerships, and benefits—EVs (car sharing), different charger types (Level 2 [L2], direct current fast charger [DCFC]), partnerships, access for MFH, and outreach—is comprehensive and shows promise of addressing community mobility needs and improving uptake of EVs as users will have access to another mobility option that is intended to serve their needs. The reviewer added that it would be great to understand how local community engagement efforts contribute to the co-design of project elements or adjusting the original project proposal, as this kind of activity supports understanding the real-world need, and what new local organizations have committed to supporting the project. The reviewer further stated that it would be good to see information about how the project objectives/outcomes align with other community/city initiatives (General Plan, Transportation Plan, etc.) as a way of supporting sustainability and aligning project benefits to other community priorities. The reviewer noted that the continued investment in outreach and partnerships is an important element, specifically, working with MFH communities supports expanding access and benefits of these technologies.

Reviewer 4:

The reviewer commented that this project’s approach for integrating advanced transportation technologies and practices aligns with and addresses the real-world challenges of integrating EVSE and EVs to provide access to electric driving in communities otherwise lacking this mobility option. The reviewer observed that the project team is using education and outreach through community events as well as marketing and social media to develop membership in the service offering. The reviewer stated that specializing in providing car sharing and targeting MFH areas, especially economically disadvantaged parts of the Twin Cities where private vehicle access is less common, are effective approaches to solve the real-world challenge of making electrification benefits available on an equitable basis to those whom historical transportation decisions have most burdened.

Question 3: Please comment on the project's progress and significant accomplishments to date.

Reviewer 1:

The reviewer observed that the project has faced some challenges with supply chain issues that have impacted how quickly charging stations and EVs could be acquired and deployed, but that, despite those challenges, there has been significant progress made on the project. The reviewer noted specifically that 2600 unique users and 63,000 trips were taken. The reviewer commented that, in light of the project team asking for an extension, the reviewer scored the project 3 and 3.5 on two successive questions. The reviewer further noted that the project team has completed one out of 10 rides and drives, and it seems that more ride and drives should have happened earlier in the implementation of the project to increase awareness and exposure to the project. The reviewer stated that one project accomplishment is that Access Plus Trips, which are based on income, are at 36% of all rides. The reviewer further stated that the project is looking to expand with four new community-based organizations (CBOs) adding 10 charger hubs in two square miles and commented that a good measure of success is that other CBOs are looking to join the project in the communities that they serve.

Reviewer 2:

The reviewer stated that the project clearly identified the challenges faced along the way and demonstrated an ability to pivot when things did not go as planned.

Reviewer 3:

The reviewer stated that deployment at five low-income MFH properties is an accomplishment, and that, given engagement and outreach priorities of this project, this will allow community members to understand how the technologies and infrastructure meet their needs and provide more feedback. The reviewer added that installation of 46 L2 charging hubs is also a good start and will be an important element in offering diverse charging options. The reviewer remarked that it would help if the map of the charging locations also included or distinguished the information about the MFH properties. The reviewer stated that collaborating with agencies and local CBOs is critical to the outreach for and deployment of infrastructure. The reviewer opined that it would be great to understand how local community engagement efforts contribute to the co-design of project elements or adjusting project elements through implementation, as this kind of activity supports understanding the real-world need, and what new local organizations have committed to supporting the project. The reviewer commended the project team for managing the vehicle recall and supply chain challenges.

Reviewer 4:

The reviewer observed that the principal investigator reported that the project is 70% complete and was originally scheduled to end in December 2023, but the team is asking for a 6-month extension due to supply chain lead times and the region's short construction season; the team is waiting on the car share program to install EVSE before leasing the corresponding EVs. The reviewer noted that positive progress can be seen, however, from the team's measuring and demonstrating steady growth in increased car share trips, exceeding 10,000 per month by March 2023. The reviewer commented that the team noted that vandalism has been a challenge, and they have added cameras to deter destructive activities involving the vehicles and EVSE. With 46 L2 charging hubs commissioned, 10 DCFC ordered, 150 deployed as a one-way car sharing network, and 21 vehicles for use at MFH secured, the reviewer found that there is good progress even though the project is behind schedule.

Question 4: Please comment on the level of collaboration within the project team and the degree to which the project team has identified and leveraged the proper connections to achieve its project goals.

Reviewer 1:

The reviewer commented that the project team has a diverse set of partners that are collaborating on this project, including government, nonprofits with specific project-related expertise, utility, industry, and community partners. The reviewer recommended in the future clearly laying out the different roles that community partners play, as they are often critical to the project being used by community members and added that it would be helpful to understand how they are being utilized. The reviewer stated that collaboration with private funders helps with the sustainability of the project. The reviewer found no notable weaknesses on the project team.

Reviewer 2:

The reviewer observed that, while not in the documentation, the project team did convey information in the presentation on the stakeholder connections and collaborations they undertook during the planning and implementation phases. The reviewer added that this effort took a level of sophistication and outreach, both from a technical perspective and a community relationship perspective.

Reviewer 3:

The reviewer commented that deployment of infrastructure and services of this kind is only available and possible as a result of collaborative partnerships—CBOs, multi-sectoral, local agency, and other community groups, and stated that establishing a connection with MFH communities is a critical factor here, too. The reviewer added that it would be great to understand how local community engagement efforts led to new local organizations participating in this project and how they will continue to be involved in supporting it when the project ends. The reviewer noted that the continued engagement and education in these communities will be helpful here.

Reviewer 4:

The reviewer noted that the principal investigator reported on the collaboration of project partners in promoting the project at community events that allow people to learn about the Evie program. The reviewer added that the American Cities Climate Challenge and involvement of the Clean Cities are ways that the team has leveraged its internal connections to achieve project goals.

Question 5: Please provide comment on the contribution of this project to energy equity and environmental justice by ensuring the project benefits underserved and overburdened communities and does not cause increased burdens to these communities.

Reviewer 1:

The reviewer noted that the project team has incorporated community engagement as a core part of the project and continues to do community engagement to increase project awareness and communicate project changes. The reviewer observed that project users are approximately 36% Access Plus Trips which means the program is reaching low-income residents. The reviewer further noted that the project is partnered with CBOs and Affordable Housing which directly serve low-income communities that historically have more barriers to transportation and to clean transportation. The reviewer commented that the project has prioritized adding new EV Hubs to areas where there are none currently and in areas of concentrated poverty, and the project is expanding the service area to add more charging and work with more CBOs. The reviewer stated that this Eastside expansion appears to be in or near an area of concentrated poverty.

Reviewer 2:

The reviewer remarked that in reviewing the documentation and the presentation, one is left to infer in some places on energy equity and environmental justice (EEEJ) benefit and stated that more direct data/information on the impact would help the evaluator.

Reviewer 3:

The reviewer commented that installing infrastructure at MFH and the outreach show that progress has been made, and there is still opportunity here to meet the communities where they are. The reviewer stated that it would be great to understand how local community engagement efforts led to new local organizations participating in this project and how they will continue to be involved in supporting it when the project ends. The reviewer said it was not possible to tell how low-income groups were included as part of the planning or design processes in the initial phase of the project—type of chargers, vehicles, and potential site hosts. The reviewer commented on a lack of information about how the project objectives/outcomes align with other community/city initiatives (General Plan, Transportation Plan, etc.) as a way of supporting sustainability and aligning EV benefits to other community priorities that identify transportation as a barrier—access to healthcare, food deserts, air pollution, etc. The reviewer found that overall, it was a good approach.

Reviewer 4:

The reviewer stated that the Twin Cities project is meaningfully contributing to EEEJ by targeting underserved communities and noted that about one third of trips through the program are Access Plus trips taken in DACs. The reviewer added that the project demonstrates a strong focus on MFH areas and Areas of Concentrated Poverty where 50% or more of residents are people of color (ACP50s).

Presentation Number: TI127
Presentation Title: The Mid-Atlantic Electrification Partnership: An Electrification Ecosystem of Intermodal Leadership and Intercity Travel
Principal Investigator: Alleyn Harned (Virginia Clean Cities)

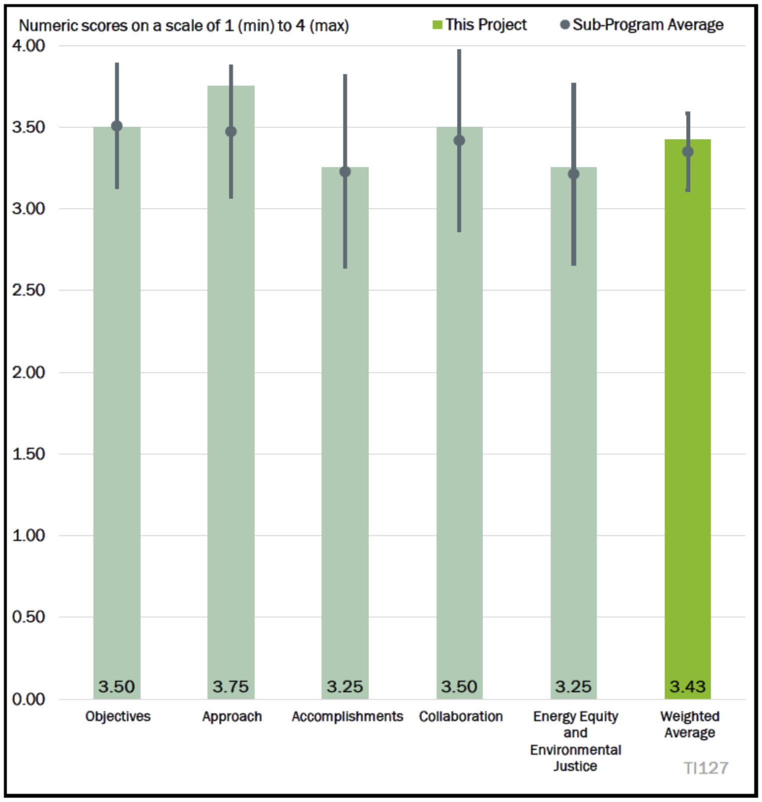

Figure 6-3 - Presentation Number: TI127 Presentation Title: The Mid-Atlantic Electrification Partnership: An Electrification Ecosystem of Intermodal Leadership and Intercity Travel Principal Investigator: Alleyn Harned (Virginia Clean Cities)

Presenter

Alleyn Harned, Virginia Clean Cities

Reviewer Sample Size

A total of two reviewers evaluated this project.

Question 1: Please provide comments on this project's degree of support for the overall Technology Integration (TI) objectives of improving fuel diversity, increasing local resiliency, and reducing greenhouse gas emissions through increasing alternative fuel use and transportation efficiency.

Reviewer 1:

The reviewer stated that the combination of infrastructure, outreach, partnerships, analysis tool, and benefits of this project support the overall TI objectives in these communities. The reviewer commented that including multiple EV types (light duty and bus) is an important element in supporting alternative fuel use and transportation efficiency, this supports other mobility options for consideration for community members, and it would help to see a timeline for deployment of these. The reviewer stated that it would be great to understand how local community engagement efforts contribute to the co-design of project elements, as this kind of activity supports resiliency, and the inclusion of new local community groups. The reviewer added that the intake call process is also an important innovation here, that offers another opportunity for community members to engage. Overall, the reviewer found an excellent degree of support for project objectives.

Reviewer 2:

The reviewer stated that this project is improving fuel diversity and GHG emissions through over 100 charging ports deployed to date and further DCFC chargers to come, as well as the new publicly available Geospatial Energy Mapper analysis tool that partner Argonne National Lab launched.

Question 2: Please comment on this project's approach for integrating advanced transportation technologies and practices to solve real-world challenges.

Reviewer 1:

The reviewer commented that the combination of infrastructure, outreach, partnerships, and benefits – multiple EVs (types), L2 chargers (affordable), partnerships, especially with Historically Black Colleges and Universities (HBCUs), and outreach is innovative and shows promise of addressing community mobility needs and improving uptake of EV technologies. The reviewer added that it would be great to understand how local community engagement efforts contribute to the co-design of project elements or adjusting the original project proposal, as this kind of activity supports understanding the real-world need, and what new local organizations have committed to supporting the project. The reviewer further commented that it would be great to see information about how the project objectives/outcomes align with other community/city initiatives (general plan, transportation plan, housing plan, etc.) as a way of supporting sustainability and aligning project benefits to other community priorities. Investment in outreach and partnerships are an important element. The reviewer noted that, specifically, administering the intake call center is a critical element that also supports expanding access and benefits of these technologies.

Reviewer 2:

The reviewer noted that the project relies on virtual and in-person education, infrastructure studies and modeling tools, and vehicle/ports planning and deployment the main approaches for integrating transportation technology and practices. The reviewer pointed out that utility capacity mapping is an approach that this project somewhat uniquely brings to the challenge.

Question 3: Please comment on the project's progress and significant accomplishments to date.

Reviewer 1:

The reviewer commented that deployment of charging stations (L2s and DCFCs) and vehicles is an accomplishment and given engagement and outreach priorities of this project this will allow community members to understand how the technologies and infrastructure meet their needs and provide more feedback to the project team. The reviewer found the intake call process to be a great element, adding that it would be helpful to know what that it is and how people find out about it. The reviewer stated that collaborating with agencies, local CBOs, and HBCUs is critical to the outreach for and deployment of infrastructure. The reviewer found managing the vehicle recall and supply chain issues to be commendable. The reviewer stated that it would be great to understand how local community engagement efforts contribute to the co-design of project elements or adjusting project elements (number of vehicles, previously unknown community groups) through implementation. Based on the presentation, the reviewer was unsure of the charging station plan/progress—375 stations for the project, then plan for 200 fast charging L2 ports, then (80 L2 ports, two hubs, and 20 DCFCs), and was unsure of the purpose/benefits of and the audience for the mapping tool, at least in its distinction from other web-based screening tools, and the technical report.

Reviewer 2:

The reviewer noted that the project is 40% complete, which appears to be behind schedule for a period of performance from November 2020 to December 2024; however, the team noted that they are ahead of schedule and targets for the consumer education task, with 27 events completed. The reviewer commented that it is also notable that the Joint Office profiled the project as a case study and that a new publicly available analysis tool launched as part of the effort.

Question 4: Please comment on the level of collaboration within the project team and the degree to which the project team has identified and leveraged the proper connections to achieve its project goals.

Reviewer 1:

The reviewer stated that the deployment of infrastructure and services of this kind is only available and possible as a result of collaborative partnerships involving the project team, CBOs, multi-sectoral, local agency, and other community groups. The reviewer added that establishing a connection with HBCUs is a critical factor here, too, as these are important community and institutional anchors. The reviewer commented that it would be great to understand how local community engagement efforts led to new local organizations participating in this project and how they will continue to be involved in supporting it when the project ends; the continued engagement and education in these communities will be critical.

Reviewer 2:

The reviewer noted that the project exhibits a robust teaming arrangement with utilities and installation firms, as well as with consultant EV Noire, Dominion Energy, and other utilities in the mid-Atlantic, including making daily grid capacity mapping data freely, publicly available to show the megawatt capacity in different locations.

Question 5: Please provide comment on the contribution of this project to energy equity and environmental justice by ensuring the project benefits underserved and overburdened communities and does not cause increased burdens to these communities.

Reviewer 1:

The reviewer commented that, through the partnership with HBCUs and intake call process, and the 80 L2s and 20 DCFCs, progress has been made, and there is still opportunity here to meet the communities where they are. The reviewer stated that the intake call process is wonderful, as is the partnership with the HBCUs. The reviewer found it difficult to tell how low-income groups were included as part of the planning or design processes in the initial phase of the project—type of chargers, vehicles, and potential site hosts. The reviewer also did not see information about how the project objectives/outcomes align with other community/city initiatives (general plan, transportation plan, other kinds of plans, etc.) as a way of supporting sustainability and aligning EV benefits to other community priorities that identify transportation as a barrier—access to healthcare, food deserts, air pollution, etc. Overall, the reviewer found it to be a good approach.

Reviewer 2:

The reviewer found that the project contributes significantly to EEEJ with 25 regional/local partners focused on rural and disadvantaged areas and noted that project partners are focusing on community pollution and expanding the economic opportunities of clean vehicles. The reviewer stated that mapping utility capacity makes it possible to put this data in front of community decision makers; however, the chargers so far are not being deployed in DACs, and the team is still figuring out metrics for and how to measure who benefits from the EV chargers.

Presentation Number: TI128
Presentation Title: Western Smart Regional Electric Vehicles Adoption and Infrastructure at Scale
Principal Investigator: James Campbell (PacifiCorp)

Presenter

James Campbell, PacifiCorp

Reviewer Sample Size

A total of three reviewers evaluated this project.

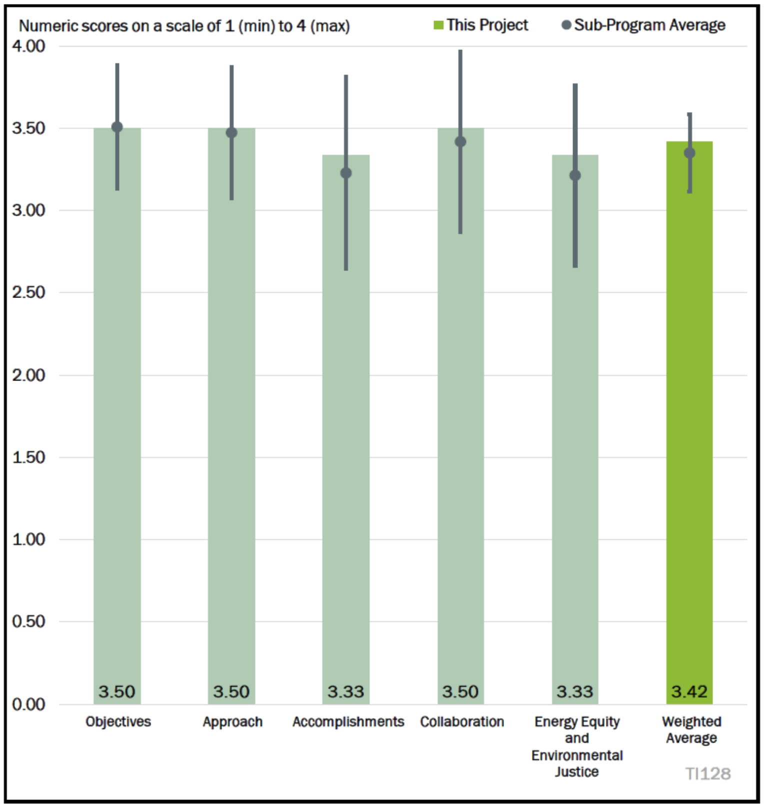

Figure 6-4 - Presentation Number: TI128 Presentation Title: Western Smart Regional Electric Vehicles Adoption and Infrastructure at Scale Principal Investigator: James Campbell (PacifiCorp)

Question 1: Please provide comments on this project's degree of support for the overall Technology Integration (TI) objectives of improving fuel diversity, increasing local resiliency, and reducing greenhouse gas emissions through increasing alternative fuel use and transportation efficiency.

Reviewer 1:

The reviewer found the presentation to be very clear in describing an approach that leveraged diverse stakeholders to make impact at a strategic/regional level and addressed mobility needs of rural and underserved communities. The reviewer commented that, while the overarching goal of the work was to create an enduring ecosystem to accelerate growth in freight, business, and consumer use of EVs in the Intermountain West, the effort also addressed workforce training and closed education gaps about alternate fuels.

Reviewer 2:

The reviewer stated that the combination of infrastructure, outreach, partnerships, and benefits of this project support the overall TI objectives in these communities and added that including multiple EV types (consumer/freight) and infrastructure at affordable housing is an important element in supporting alternative fuel use and transportation efficiency, and this supports another mobility option for community members. The reviewer commented that the EV training activities are also an important element here, that offer another opportunity to engage community members and an opportunity for them to learn new skills. The reviewer suggested that it would be great to understand how local community engagement efforts contribute to the co-design of project elements, as this kind of activity supports resiliency. Overall, the reviewer found an excellent degree of support for objectives.

Reviewer 3:

The reviewer found that this project addresses the TI objectives of fuel diversity and reducing GHG emissions as it considers multiple transportation modes: freight, business, and consumer, and it also addresses resilience by planning for grid impacts and planning for reliability. The reviewer pointed out that, amidst the broad scope, the project appears to lack a plan for defining and measuring success. The reviewer stated that, per the discussion, infrastructure metrics were straightforward to set up, as were the number of affordable housing residents using EVs, but it is unclear how the "30% EV adoption" target relates to success metrics for the many individual sub-projects or for the project as a whole.

Question 2: Please comment on this project's approach for integrating advanced transportation technologies and practices to solve real-world challenges.

Reviewer 1:

The reviewer commented that the project addressed challenges both at a fleet level and for personal mobility, and the work included Clean Cities, International Brotherhood of Electrical Workers, academics, and utilities. The reviewer noted that, often, there are competing interests in diverse working groups such as this and the management approach to align the work helped to achieve the goals. The reviewer stated that this would be a good model to replicate in other regions of the US.

Reviewer 2:

The reviewer stated that the combination of infrastructure, outreach, partnerships, and benefits—multiple EVs (types), mobile training, partnerships, and outreach—is innovative and shows promise of addressing community mobility needs and improving uptake of EV technologies and added that investment in outreach and partnerships is an important element. The reviewer commented that, specifically, deploying a mobile education unit for rural students is a critical element that also supports expanding access and benefits of these technologies, and upskilling the workforce, and aligning with existing public transportation infrastructure (Union Station) will support sustainability, accessibility, and intermodal activities. The reviewer questioned what the preliminary timeline for the intermodal/heavy duty vehicles portion of project is. The reviewer commented that it would be great to understand how local community engagement efforts contribute to the co-design of project elements or adjusting the original project proposal, as this kind of activity supports understanding the real-world need, and what new local orgs have committed to supporting the project. The reviewer further commented that it would be great to see information about how the project objectives/outcomes align with other community/city initiatives (General Plan, Transportation Plan, Housing Plan, etc.) as a way of supporting sustainability and aligning project benefits to other community priorities.

Reviewer 3:

The reviewer commented that the project approach extends beyond interstate corridors, and the approach of co-locating charging infrastructure seems like an effective approach to integrate the technologies for multiple modes with reduced grid costs. The reviewer noted that the project has a portfolio of five focus areas incorporating multiple modes and community use types, and generally has a modeling/planning/design phase followed by implementation and operation followed by outreach and education. The reviewer stated that the approach seems to miss a need for outreach and education earlier in the cycle, as part of planning and before deployment.

Question 3: Please comment on the project's progress and significant accomplishments to date.

Reviewer 1:

The reviewer found that the effort has delivered on the stated goals, and the only barriers to success were outside of the scope of control of the team: supply chain and labor shortages. The reviewer noted that the project leveraged a cost share that created a fusion of corporate sponsorship and governmental funds through the match and has a demonstrated positive return on the investment.

Reviewer 2:

The reviewer commented that it seems like most of the project activity is still in the design and planning phase, and this makes it hard to assess any actual impacts. The reviewer noted that it would help to understand how DACs were provided access to the planning and design process. The reviewer found the EV car share to be a good start but was unsure what the usage means or the proximity of the service with respect to where the users live, and whether the "intermodal hub" is the "e-mobility hub" and that the hub is the proposed Union Station location. The reviewer questioned what the outcome in this project for the port electrification element is, and how the national parks and recreation electrification element different or aligned with the National Park Service Electric Vehicle Transition plan from February 2023. The reviewer noted the supply chain challenge and the challenge of finding qualified staff for such a large area. The reviewer expressed an eagerness for the roll-out of the mobile unit and believes this can be a near-term impact for good.

Reviewer 3:

The reviewer noted that the project is 33% complete, which is behind schedule based on the October 2020 to December 2024 period of performance. The reviewer commented that the team is currently designing infrastructure the National Park in Moab and noted that they required a no-cost extension prior to the National Electric Vehicle Infrastructure (NEVI) Formula Program due to long lead times for procuring DCFC supplies, and they are not sure how much longer the lead times might become post-NEVI. The reviewer observed that the EV workforce training for rural communities has created and is using a mobile education unit, and the principal investigator reported that the EV car share with Nissan Leaf and Chevrolet Bolt models has been utilized by affordable housing residents, mostly new residents and refugees.

Question 4: Please comment on the level of collaboration within the project team and the degree to which the project team has identified and leveraged the proper connections to achieve its project goals.

Reviewer 1:

The reviewer commented that this effort created a fusion of thought leaders from industry, non-profits, academics, and others to work in a unified manner to achieve the project goals. The reviewer added that the management structure appears to have created a unified and successful initiative and potentially sets a foundation for future collaboration to meet environmental goals.

Reviewer 2:

The reviewer stated that the deployment of infrastructure and services of this kind is only available and possible as a result of collaborative partnerships—project team, CBOs, multi-sectoral, local agency, and other community groups; however, as there is limited implementation activity, it is difficult to assess this question. The reviewer found the partnerships for the mobile unit, and along the corridors to be good and necessary. The reviewer added that it would be great to understand how local community engagement efforts led to new local organizations participating in this project and how they will continue to be involved in supporting when the project ends. The reviewer observed that delays in the supply chain may have an impact on implementation.

Reviewer 3:

The reviewer noted that the level of collaboration seems high on the project, based on the multiple Clean Cities Coalitions committed as partners, and that it is a very large team of academia, national laboratories, utilities, Clean Cities, cities, non-governmental organizations (NGOs), port/airports, and the private sector. The reviewer stated that it is a little unclear how the partner roles are allotted, including among the five focus areas, with a portfolio of projects including urban and rural mobility components, electric bus and car share, freight and port applications.

Question 5: Please provide comment on the contribution of this project to energy equity and environmental justice by ensuring the project benefits underserved and overburdened communities and does not cause increased burdens to these communities.

Reviewer 1:

The reviewer noted that the project profiles an EV car sharing deployment in an affordable housing community called Giv Community and gives transparent findings on the obstacles and opportunities that the nonprofit arm of a leading MFH development organization faced in its effort to create urban mobility solutions with EV car share for residents living in low-income areas. The reviewer added that, similarly, training through the Crater Lakes Training Center has the potential to improve economic futures for rural Electricians Pre-Apprenticeship Program through rural community and school connections.

Reviewer 2:

The reviewer noted that there are good elements in this project to provide project benefits to underserved and overburdened communities, but added that, given the reliance on the highway network and the scale, it is hard to see where DACs are located in relation to existing infrastructure, and how they are selected to participate in the planning process and serve as potential site host. The reviewer found EV car share to be a great start and noted that it would help to see more information about that implementation—trip types, distance, peak usage times, etc. The reviewer did not see information about how the overall project objectives/outcomes align with other community/city initiatives (General Plan, Transportation Plan, other kinds of plans, etc.) as a way of supporting sustainability and aligning EV benefits to other community priorities that identify transportation as a barrier—like access to healthcare, food deserts, air pollution, etc. Overall, the reviewer found it to be a good approach for such a large region.

Reviewer 3:

The reviewer found that the project brings a good contribution to EEEJ, based on three of the 12 sub-projects categorized as being for underserved regions, which is one of the five focus areas. The reviewer noted that these subprojects include e-buses, EV car share, and affordable housing, and stated that four of the five focus areas may have equity benefits, but that is less clear. Additionally, the reviewer noted that the EV training pre-apprenticeship program is intended to benefit tribal and coal communities.

Presentation Number: TI129
Presentation Title: Helping America's Rural Counties Transition to Cleaner Fuels and Vehicles
Principal Investigator: Ken Brown (AKB Strategies)

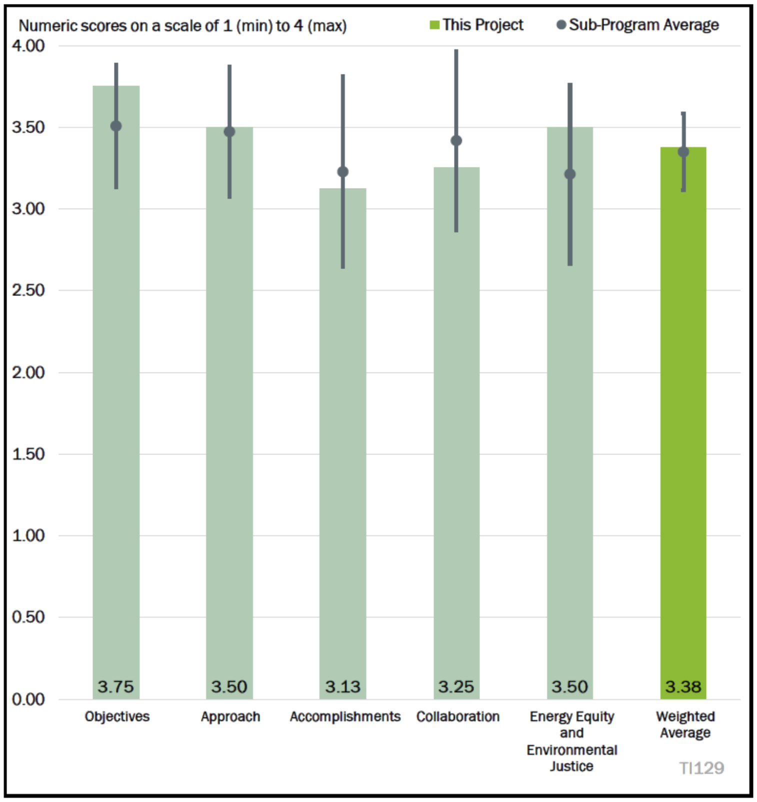

Figure 6-5 - Presentation Number: TI129 Presentation Title: Helping America's Rural Counties Transition to Cleaner Fuels and Vehicles Principal Investigator: Ken Brown (AKB Strategies)

Presenter

Ken Brown, AKB Strategies

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Please provide comments on this project's degree of support for the overall Technology Integration (TI) objectives of improving fuel diversity, increasing local resiliency, and reducing greenhouse gas emissions through increasing alternative fuel use and transportation efficiency.

Reviewer 1:

The reviewer observed that the project tackles a variety of tough barriers in rural areas across a diversity of states, which is both a strength, and a potential weakness of the work. The reviewer commented that as the project comes to a conclusion and develops its 'playbook' it will be important to pull common lessons and recommendations out of this diverse set of projects and tasks.

Reviewer 2:

The reviewer commented that this project directly supports the TI program's objective of improving fuel diversity through the use of alternative fuels, specifically in this project focusing on rural communities. The reviewer noted that the objective of the project is to work with rural communities to understand their challenges in implementing alternative fuel vehicles (AFVs) and then distribute a playbook of lessons learned so that successes can be replicated across the country. The reviewer found that this project would provide Clean Cities coalitions with important information on how to work with rural communities in their area.

Reviewer 3:

The reviewer found that this project's objectives outline a specific and effective solution for helping rural counties understand clean fuel alternatives, assess their needs, and plan for incorporating clean fuel vehicles into their fleets. The reviewer noted that the project objectives also include the important step of making the results available for other communities to follow suit in the future.

Reviewer 4:

The reviewer determined that this project meets three of the four TI objectives, the missing objective being transportation efficiency, and found that the technical assistance provided to the fleets was critical to the success of these projects. The reviewer stated that it is great that this was able to be provided to communities.

Question 2: Please comment on this project's approach for integrating advanced transportation technologies and practices to solve real-world challenges.

Reviewer 1:

The reviewer appreciated the focus on rural counties within diverse states, and on a variety of vehicles and use cases, but noted that this also makes the project a lot more complex.

Reviewer 2:

The reviewer commented that the project approach seems to mirror the successful strategies of Clean Cities coalitions working with stakeholders to implement projects and noted that one of the key factors often cited in successful projects is having a "champion" within the organization that is deploying vehicles and noted that the ultimate goal is to find local leaders that could be used as national spokespersons. The reviewer observed that the project obtained a range of industry partners to cover a wide variety fuel and powertrain types, which will help with the success of the effort by allowing communities to have the options to choose what vehicles make sense for them. The reviewer noted that the approach involves connecting these communities with subject matter experts, and that one challenge of this approach is that it seems the project is relying on industry partners representing a specific fuel to be the experts; the project team will need to make sure that the Clean Cities coalitions act as the neutral party to provide unbiased information.

Reviewer 3:

The reviewer observed that the project is being implemented in numerous counties across several states, and that a replication handbook and resources will be made available once the project is complete. The reviewer stated that providing demonstration vehicles, fleet assessments, workshops and access to experts is a comprehensive approach to help fleet managers and officials come up with the correct solution for their unique situations but indicated that information on how the project approach addresses the barrier of "limited resources to provide the upfront financing often needed to purchase clean fuels and vehicles," as stated in the project objectives, was missing. The reviewer questions what other purchasing assistance or information has been offered, aside from the virtual U.S. Department of Agriculture (USDA) Community Facilities Grant Workshop, which discussed grant funding for AFVs for rural areas.

Reviewer 4:

The reviewer found that outreach and education paired with technical assistance and demonstration events is a perfect way to introduce technology to those who may not be familiar with it in an easy to understand, non-threatening way. The reviewer indicated that this shows that the project team thought about more than just providing technical assistance and took the extra steps to really make people more comfortable first before changing things. The reviewer commented that this is a great example of the phrase "go slow to go fast."

Question 3: Please comment on the project's progress and significant accomplishments to date.

Reviewer 1:

The reviewer noted good progress on specific tasks and stated that developing and disseminating the broader common lessons learned and recommendations will be critical.

Reviewer 2:

The reviewer commented that the major accomplishment of the project so far was able to identify fifteen "champions" in the eight states that are part of the project; in addition, eight demonstration vehicles were contracted with project partners. The reviewer noted that supply chain issues have impacted the availability of vehicles for this project, which has significantly delayed the project and could limit the success of the engagement with the community leaders. The reviewer observed that the project was able to complete its national outreach webinars and coalitions have completed their stated goal of twenty-four outreach events with at least three performed in each state as of the presentation; budget period (BP) 2 milestones were still in progress, with the key efforts being in-depth technical assistance for 24 target counties in eight states, provided by Clean Cities coalitions, along with more than 40 total vehicle demonstrations. The reviewer noted that demonstration vehicles have been hard to get into the fleets' hands, and this has been the key issue in extending the project; showing vehicles in nearby communities has been way to try to deal with this.

Reviewer 3:

The reviewer observed that with 15 days left in BP 2, none of the stated objectives for the period were listed as accomplished; all were still in progress. The reviewer noted that the presenter did discuss what those ongoing efforts were, and a good amount of progress has been made, but indicated that it would have been more reassuring to know that some tasks had been fully completed.

Reviewer 4:

The reviewer stated that the project has provided outreach, education technical assistance and demonstration events to numerous fleets, thereby expanding the possibilities of these fleets. The reviewer found that the project has accomplished a great deal.

Question 4: Please comment on the level of collaboration within the project team and the degree to which the project team has identified and leveraged the proper connections to achieve its project goals.

Reviewer 1:

The reviewer observed that there seems to be great collaboration within and across states, and reasonable industry participation, but having more dissemination partners involved from an earlier point in the project to ensure that the lessons being learned will have a broader impact would have been helpful.

Reviewer 2:

The reviewer noted that the Clean Cities coalitions have a strong history of working well together and have selected industry partners that have done significant work to support the Clean Cities mission; the presentation stated that the coalitions are having monthly calls, while also doing quarterly all team meetings. The reviewer stated that it was unclear how the project is managing the collaboration and coordination of the project as it is reaching the fleet analysis stage, and they are collecting lessons learned. The reviewer added that it seems that some of the industry partners have not been able to deliver vehicles that were crucial in the success of the project.

Reviewer 3:

The reviewer observed that the project is made up of a strong team of industry and Clean Cities coalition partners. The reviewer found the accomplishments from Virginia, given as an example, are comprehensive and wide-ranging, and noted that the approach of making personal connections with local officials through in-person visits shows that coalition partners will be actively involved.

Reviewer 4:

The reviewer commented that the project team seemed to work well together and bring varying expertise to the table.

Question 5: Please provide comment on the contribution of this project to energy equity and environmental justice by ensuring the project benefits underserved and overburdened communities and does not cause increased burdens to these communities.

Reviewer 1:

The reviewer stated that rural communities face unique barriers and challenges. The reviewer observed that the project did not explicitly address race and income issues and how they intersect with rural communities and commented that there is a big difference between a rural county in eastern Oregon and a rural county in Alabama.

Reviewer 2:

The reviewer stated that the project is focused on supporting rural communities with resources to effectively analyze the use of alternative fuel vehicles in their areas and noted that the project includes rural areas in eight different states (with the goal of working in 24 counties), which will provide geographic variety. The reviewer found that this variety will be beneficial as different communities have different priorities and being able to work through those issues should provide significant lessons learned for others trying to implement projects in their rural communities. The reviewer noted that it was stated that cost savings have typically been a key focus, as well as downtime, for rural communities looking at alternative fuel vehicles and commented that this project offers the chance to demonstrate vehicles to new communities and may provide those benefits as well as others benefits including lower emissions and fuel diversity.

Reviewer 3:

The reviewer noted that the project specifically targets traditionally under-served rural areas of the country that often face unique challenges in acquiring the information and expertise, staff capacity, and funding needed to explore and utilize new technologies.

Reviewer 4:

The reviewer observed that rural communities often get overlooked when people think about underserved communities and appreciated that the project specifically targeted rural communities.

Presentation Number: TI130
Presentation Title: VoICE-MR: Vocation Integrated Cost Estimation for Maintenance and Repair of Alternative Fuel Vehicles (AFV)
Principal Investigator: Arvind Thiruvengadam (West Virginia University)

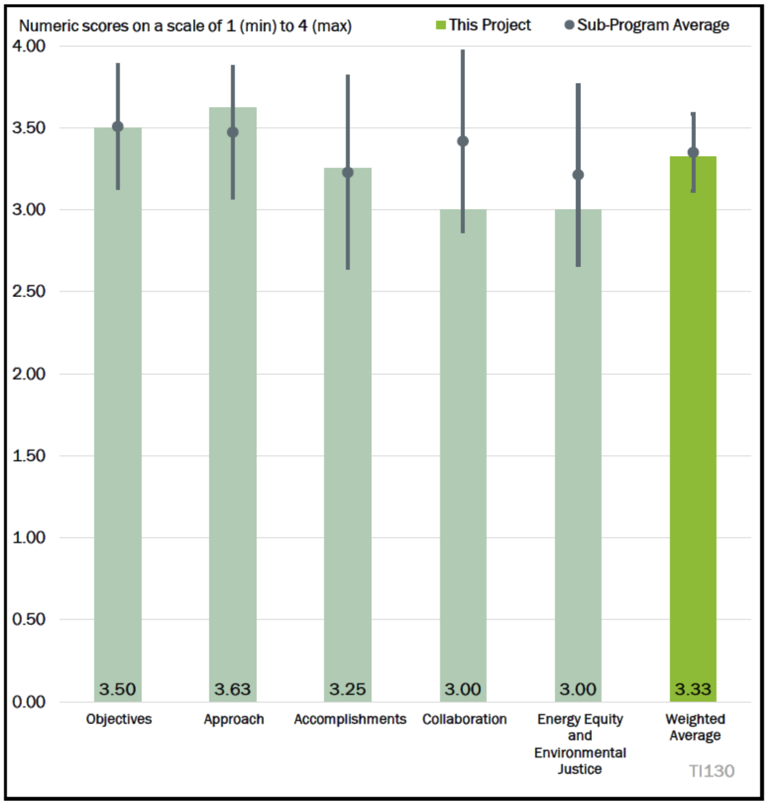

Figure 6-6 - Presentation Number: TI130 Presentation Title: VoICE-MR: Vocation Integrated Cost Estimation for Maintenance and Repair of Alternative Fuel Vehicles (AFV) Principal Investigator: Arvind Thiruvengadam (West Virginia University)

Presenter

Gregory Thompson, West Virginia University

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Please provide comments on this project's degree of support for the overall Technology Integration (TI) objectives of improving fuel diversity, increasing local resiliency, and reducing greenhouse gas emissions through increasing alternative fuel use and transportation efficiency.

Reviewer 1:

The reviewer stated that this effort addresses a key data gap when performing cost of ownership analysis of heavy-duty (HD) alternative fuel vehicles versus their diesel counterparts by examining the potential maintenance savings that AFVs may provide based on fuel type, vocation, and geographic region. The reviewer noted that public maintenance data is very limited for both diesel with new aftertreatment technologies (selective catalytic reduction and particulate filters) and AFVs, and if the data shows that there are clear maintenance savings for certain AFVs this would help in the deployment of these technologies, which would improve fuel diversity and potentially improve resiliency. The reviewer added that this may also lead to GHG benefits, but not necessarily as fossil natural gas and propane vehicles may not provide much if any benefits, even though they have lower maintenance costs.

Reviewer 2:

The reviewer noted that the project conducts an in-depth survey of HD fleets operating in various vocations to collect maintenance records for diesel and alternative fuel vehicles and analyzes vehicle telemetry data to discern the effects of duty on maintenance cost of AFVs in different vehicle vocations. The reviewer indicated that the project will examine the impact of extreme seasonal temperature changes on the maintenance cost of AFVs, and develop the Vocation Integrated Cost Estimation for Maintenance and Repair (VoICE-MR) of AFVs.

Reviewer 3:

The reviewer commented that the project is focused on furthering knowledge in the area of Heavy-Duty AFV maintenance to compare it to conventionally fueled vehicles and added that this has been difficult information to obtain but is critical to support fleet decision-making to allow for greater penetrations of cleaner vehicles.

Reviewer 4:

The reviewer stated that collecting this data and providing the analysis is key to informing decision making of businesses evaluating alternative fuels and added that the lack of good data is a major barrier, so this is a very worthwhile project.

Question 2: Please comment on this project's approach for integrating advanced transportation technologies and practices to solve real-world challenges.

Reviewer 1:

The reviewer indicated that the key to success of this project is being able to collect significant amounts of maintenance and repair data from a variety of fleets and vehicles efficiently, and that the project benefits from being able to leverage data collection from one of its partner's projects at the South Coast Air Quality Management District (SCAQMD). The reviewer added that the challenge of this type of effort is that while it is beneficial to collect as much data as possible from a wide variety of fleets, this can lead to significant data cleaning efforts by the project team due to the variability in record-keeping of different fleets. The reviewer noted that another part of the project is the effort to tie maintenance cost data to the vehicle's duty cycle through the use of telemetry data and other factors such as ambient temperatures and vehicle age, which is an important factor to understand as anecdotal discussions of maintenance of diesel vehicles with the most recent aftertreatment technologies have suggested that low speed and low load conditions were problematic. The reviewer noted that it is necessary to differentiate duty cycles when doing comparisons with alternative fuel vehicles. The reviewer added that another major component of the project is creating a machine learning model to estimate maintenance costs based on duty cycle but found that, from the presentation, it is not clear how the machine learning aspects of the project will be implemented and how the project team will mitigate biases in training this model.

Reviewer 2:

The reviewer found the project took a solid approach to a difficult data set to make accurate assessments and noted that data sanitization was the first step before converting paper records to electronic format. The reviewer observed that the converted data fleet maintenance records categories are defined by project scope, data is classified to include duty cycle and seasonal temperatures, and all data is put into a database using Microsoft PowerBi to analyze maintenance cost for diesel and alternative fuel vehicles. The reviewer added that PowerBi is a powerful tool that simplifies the data categorization process through relational database and provides flexibility in categorizing the data with multiple filters based on unique identifiers such as vocation, truck sub-system, and types of maintenance.

Reviewer 3:

The reviewer stated that the approach is complex, but that it is necessary to address the issues associated with collection and analysis of this type of information. In particular, the reviewer noted that the approach emphasizes the fleet operators who have agreed to share data, a critical element, and the project variables evaluated include weather, age of vehicle, etc.—the types of analysis that will really help fleets in their decision-making.

Reviewer 4:

The reviewer noted a very detailed approach with lots of steps and lots of parties involved. The reviewer pointed out that the one issue however is that technology is a moving target as newer, better engines and vehicles are produced each year and, in some cases, newer systems might be more efficient but also more complex and more expensive to maintain. The reviewer noted that it was unclear how the project team can address that in this project.

Question 3: Please comment on the project's progress and significant accomplishments to date.

Reviewer 1:

The reviewer commented that the project looks to be behind schedule as key tasks in BP 2 have not been finished yet, including combining duty-cycle telemetry data with maintenance data and their correlation analysis between maintenance and seasons, and posited that the loss of the original principal investigator to another position has impacted the project. The reviewer cited as good news that data collection was completed with 285 vehicles providing more than 20,000 maintenance cost records, and for most fleets they have 4 to 5 years of vehicle history, which helps in understanding cost trends. The reviewer noted that, with the data breaking out corrective actions from periodic and preventative maintenance, it makes the comparison of data between powertrains more likely to be based on technology; however, it will be quite important to understand how high-cost corrective actions impact these comparisons. The reviewer surmised that the public would want to know the expected frequency of high-cost corrective actions and stated that it would be useful to know if the data shows any trends specific to duty-cycles, engine/vehicle manufacturers, or engine size based on duty-cycle. The reviewer noted the higher failure rates for natural gas (NG) goods movement vehicles primarily operating as port drayage trucks and stated that it would be useful to know if those trucks were running engines too small for the loads (e.g., using 8.9 L when a 11.9 L should have been used).

Reviewer 2:

The reviewer noted that Data Classification and Analysis collected by the project was from a total of 72 diesel, 86 propane, 102 natural gas and 25 electric HD vehicles and the project has collected a total of 7,000 maintenance cost records for diesel, 13,000 records for natural gas vehicles (NGV) and 1,800 records for propane. Data is being processed for EVs from a large transit fleet, and geographical regions covered include the Mid-Atlantic, Midwest, East Coast, Southwest and Central regions of the country. The reviewer added that vehicle model years range from 2008-2018 with historical maintenance records spanning from 2015–2021, new telemetry data from vehicle operation in the East Coast of the U.S. has been collected, and model development for predicting maintenance cost based on vocation characteristics has begun.

Reviewer 3:

The reviewer observed that the team is currently evaluating the data, particularly seasonal and temperature variables, and that this includes as much as the past decade of data on some of the diesel, compressed natural gas (CNG), and liquefied petroleum gas (LPG or propane) vehicles. The reviewer noted that the LPG data was for school buses, so there are some variations by vocation, and the project team has already identified some key differences between diesel and alternative fuel vehicles, with additional variation by vocation. The reviewer commented that there does seem to be a significant portion of work left (by the team's own admission, 30%), with only about six months left in the project.

Reviewer 4:

The reviewer commented that the fact that they are on track and are able to draw some conclusions about problems exhibited with different technologies is very positive.

Question 4: Please comment on the level of collaboration within the project team and the degree to which the project team has identified and leveraged the proper connections to achieve its project goals.

Reviewer 1:

The reviewer mentioned that Clean Cities coalition directors have helped with initial conversations to introduce fleets to West Virginia University (WVU), but that delays in subaward agreements with Clean Cities coalitions has slowed participation. The reviewer commented that it was stated that funding partners help target which fleets to go after, but the process was not explained very well. The reviewer observed that WVU is doing most of the work for BP 2 and BP 3.

Reviewer 2:

The reviewer found the project team to be very strong, including the South Coast Air Quality Management District, Southern California Gas Company, Michael Lee Project Partners, Wale and Associates Corp., Western Riverside Council of Governments, Pittsburg Region Clean Cites, West Virginia Clean Cities and Propane Education and Research Council. The reviewer opined that this group has an industry respected acumen to perform an accurate assessment for the project.

Reviewer 3:

The reviewer observed that the project team includes a number of Clean Cities coalitions, several fleets, and one alternative fuel association, but indicated that it would have been expected that more alternative fuel organizations might have been involved to help expand the opportunity for outreach. The reviewer noted that in addition both fleets lined up to provide data were in California and indicated that it probably would have been better to have included some more geographic spread. The reviewer noted that there are regular team meetings.

Reviewer 4:

The reviewer noted that this project involves a significant number of participants and a lot of data that must be reviewed and added that others have had difficulty getting similar data, so it is excellent that they are on track.

Question 5: Please provide comment on the contribution of this project to energy equity and environmental justice by ensuring the project benefits underserved and overburdened communities and does not cause increased burdens to these communities.

Reviewer 1:

The reviewer commented that it is difficult to grade this project on EEEJ, as the focus is on collecting data to support fleet decision-making; ultimately, the data from this project can lead to increased AFV adoption, which may provide emissions benefits to communities in both rural and underserved areas. The reviewer added that the project is trying to get data in rural regions and help fleets in those areas to understand their experience, though it is not clear how successful it has been so far at this.

Reviewer 2:

The reviewer noted that the project will address the gaps in knowledge related to wide-scale adoption of alternative fuel vehicles in rural regions of the country as well as increasing the use of domestic and cleaner fuels in HD vocations not restricted to urban locations.

Reviewer 3:

The reviewer concluded that the project would provide some benefit to overburdened communities by improving the prospects of alternative fuel vehicles, particularly MD and HD urban-based vehicles; however, the project has not really drawn a strong connection on this issue.

Reviewer 4:

The reviewer stated that a project like this will only have benefit to affected communities down the road as results and data are used to influence purchase decisions, so a good ranking is probably as high as you could get for a project like this.

Presentation Number: TI131
Presentation Title: DRIVE (Developing Replicable, Innovative Variants for Engagement) for EVs in the USA
Principal Investigator: Jonathan Overly (East Tennessee Clean Fuels Coalition)

Presenter

Jonathan Overly, East Tennessee Clean Fuels Coalition

Reviewer Sample Size

A total of three reviewers evaluated this project.

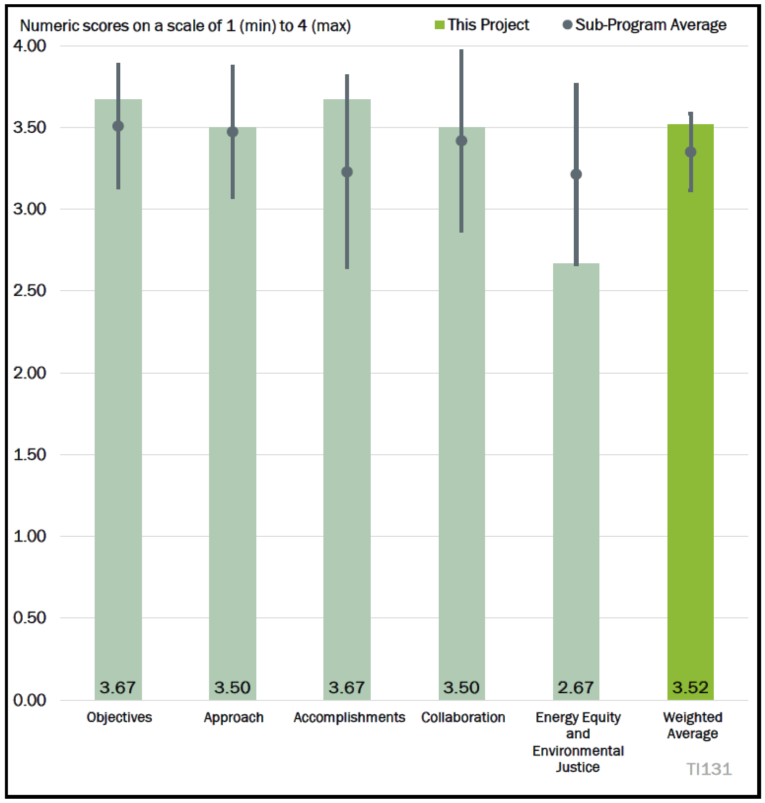

Figure 6-7 - Presentation Number: TI131 Presentation Title: DRIVE (Developing Replicable, Innovative Variants for Engagement) for EVs in the USA Principal Investigator: Jonathan Overly (East Tennessee Clean Fuels Coalition)

Question 1: Please provide comments on this project's degree of support for the overall Technology Integration (TI) objectives of improving fuel diversity, increasing local resiliency, and reducing greenhouse gas emissions through increasing alternative fuel use and transportation efficiency.

Reviewer 1:

The reviewer commented that this is a massive and sprawling project including seven major activity areas across 14 states and many, many activities.

Reviewer 2:

The reviewer stated that the project promotes, educates, and works to remove other barriers to the adoption of electric transportation, directly supporting TI's fuel diversity objectives and goal to increase alternative fuel use and transportation efficiency. The reviewer added that the project is designed to address barriers on every level: consumers/fleets, infrastructure/government, dealerships/utilities. The reviewer noted that the project was created with the goal of supporting electric transportation in an impressive seven key areas.

Reviewer 3:

The reviewer commented that this project is laying the groundwork to meet these objectives in each state they work in.

Question 2: Please comment on this project's approach for integrating advanced transportation technologies and practices to solve real-world challenges.

Reviewer 1:

The reviewer stated that this project is large, sprawling, and diverse and expressed the view that to maximize its value, and ensure it is not just "random acts of EV kindness," it will be critically important that this project extract key lessons learned, most promising strategies, etc.

Reviewer 2:

The reviewer noted that the Project lead looked to Clean Cities coalitions (supporters of alternative transportation fuels) for partnership, and that these partners were already promoting clean transportation and this project, and its scope gave them a chance to formalize promotion of EVs; in effect, this project became a program. The reviewer stated that goals are organized, and websites established, and the seven priority areas are created to address nearly all players in EV adoption (minus original equipment manufacturers [OEMs], upfitters) allowing partners a template from which to design their chapter, with the team providing support through meetings, retreats.

Reviewer 3:

The reviewer commented that offering a charging gap analysis and a policy play book to these communities reduces a lot of the stress and work that decision makers have and enables a smooth transition to EVs.

Question 3: Please comment on the project's progress and significant accomplishments to date.

Reviewer 1:

The reviewer noted that lots of good work has been done but suggested that the key question is whether and how this work continues, evolves, and can be replicated. The reviewer noted an aspiration to build a long-term program or campaign but stated that it is not clear that there is a viable funding/business model. The reviewer opined that this work seems like core operations for Clean Cities coalitions, and either DOE needs to fund this work indefinitely or it is unlikely to continue.

Reviewer 2:

The reviewer noted that the project lead successfully accomplished the establishment of Drive Electric USA, and in the remaining months of this project, the focus will be on utility, government, and dealership engagement, and on creating a replication playbook. The reviewer stated that a replication playbook made available to all Clean Cities coalitions and other relevant organizations will provide the direction needed to establish more chapters and beyond the end date, some chapters will continue Dive Electric USA, providing support for EV adoption well beyond this project. The reviewer suggested that providing funding for Drive Electric USA as an established program would help chapters to grow and remain strong and up to date.

Reviewer 3:

The reviewer commented that this project has progressed well in its 2 years.

Question 4: Please comment on the level of collaboration within the project team and the degree to which the project team has identified and leveraged the proper connections to achieve its project goals.

Reviewer 1:

The reviewer stated that there seems to be good coordination among states, but it is less clear how well this effort is coordinating with industry, utilities, and other stakeholders. The reviewer noted that this will be increasingly important if the work continues, e.g. coordination with VTO-funded outreach projects, Plugstar, OEM marketing, etc.

Reviewer 2:

The reviewer commented that Clean Cities coalition directors are a dynamic group, and while thirteen partners is a lot to manage, most are likely enthusiastic and highly motivated. The reviewer noted that retreats, monthly meetings, and posting success stories are effective ways to keep the effort level up, and the creation of a steering committee was a good idea.

Reviewer 3:

The reviewer stated that this project team brought together a lot of partners.

Question 5: Please provide comment on the contribution of this project to energy equity and environmental justice by ensuring the project benefits underserved and overburdened communities and does not cause increased burdens to these communities.

Reviewer 1:

The reviewer commented that this project was launched under a different set of guidelines and expectations but given the project breadth there could have been more emphasis on equity and issues related to the Justice40 Initiative in project execution.

Reviewer 2:

The reviewer noted that the presenter stated that at the time the project was created EEEJ was not a focus; however, one of the project objectives is to build EV awareness and adoption in rural communities.

Reviewer 3:

The reviewer stated that the project could have carved out specific space for Black, Indigenous, People of Color (BIPOC) and limited income community outreach. The reviewer commented that the rural outreach was great and appreciated the project lead acknowledging that they could have been stronger in this area and are taking steps to be better.

Presentation Number: TI132
Presentation Title: NFPA Spurs the Safe Adoption of Electric Vehicles through Education and Outreach
Principal Investigator: Andrew Klock (National Fire Protection Association)

Presenter

Andrew Klock, National Fire Protection Association

Reviewer Sample Size

A total of four reviewers evaluated this project.

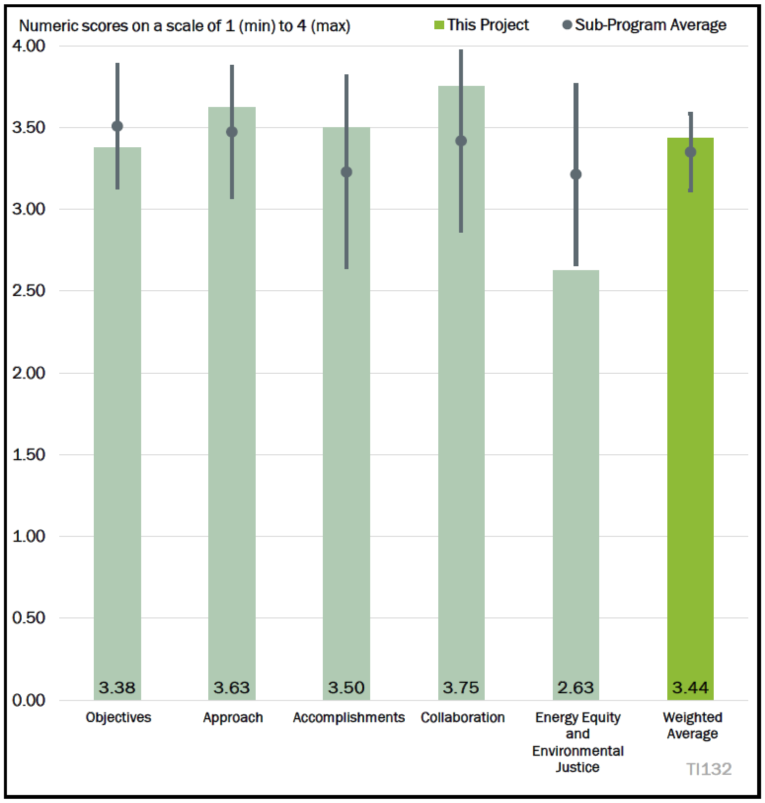

Figure 6-8 - Presentation Number: TI132 Presentation Title: NFPA Spurs the Safe Adoption of Electric Vehicles through Education and Outreach Principal Investigator: Andrew Klock (National Fire Protection Association)

Question 1: Please provide comments on this project's degree of support for the overall Technology Integration (TI) objectives of improving fuel diversity, increasing local resiliency, and reducing greenhouse gas emissions through increasing alternative fuel use and transportation efficiency.

Reviewer 1:

The reviewer commented that issues of safety for first responders, etc,. are critical as EVs scale, and there is a ton of misinformation and fearmongering in this space so having credible, objective information and training like this is crucial.

Reviewer 2:

The reviewer stated that this project addresses one of the obstacles to EV adoption—knowledge gaps for stakeholders about the electric vehicle (EV) ecosystem. The reviewer noted that the team had built products such as the EV Community Preparedness Assessment Workshop curriculum and toolkit for Clean Cities coalitions and had successfully delivered 30 virtual EV Community Preparedness Assessment Workshops nationwide in major cities to kickstart planning and preparedness for EV adoption.

Reviewer 3:

The reviewer found that the project objectives offer a great deal of support for the overall TI objectives of increasing alternative fuel use and transportation efficiency and noted that education is a key component of fostering the adoption of EVs, and this program has an all-encompassing approach.

Reviewer 4:

The reviewer expressed the view that this project increases local resiliency and tamps fears about EVs, and these trainings should be taken and given in every community; however, the project does not achieve the other three project objectives.

Question 2: Please comment on this project's approach for integrating advanced transportation technologies and practices to solve real-world challenges.

Reviewer 1:

The reviewer stated that developing online training, modules for different audiences and face-to-face workshops seems a solid approach, but expressed skepticism that Clean Cities coalitions are the best or only delivery system for this kind of training; the reviewer favored an approach that works more through appropriate intermediaries for each market (e.g., dealer associations, police associations, etc.). The reviewer speculated that this was a byproduct of DOE funding constraints that require large investments and partnerships with Clean Cities coalitions but commented that this likely made the project less impactful.

Reviewer 2:

The reviewer noted that the team took on a challenge to create content to bridge knowledge gaps and described the use of webinars and in-person events, but the presentation and documentation was lacking information to measure and/or understand the impact of this effort on communities. The reviewer noted that content creation for this training takes time and speculated that this is why communities where training will take place have been identified, but actual training is pending.

Reviewer 3:

The reviewer commented that developing online/virtual training courses was a great approach during the pandemic when this project was being planned, and pivoting to include in-person training for the same curriculum after the pandemic was even better. The reviewer added that targeting the entire "EV Ecosystem" of consumers, fleets, towing, dealers, insurance, first responders, etc., with the curriculum/training shows good thinking and showcases why National Fire Protection Association (NFPA) is a strong lead for this project. The reviewer noted that creation of the "Ready for EVs" website is a great addition to the project, helping to ensure that the project accomplishments and resources will live beyond the project's end date.

Reviewer 4:

The reviewer noted that this project was able to pivot from in person to virtual at a time where that was critical to the success of these trainings and added that if this pivot had not been made the project would have had to be on hold indefinitely. The reviewer noted that this project also uses in person workshops for tangible interaction with these technologies.

Question 3: Please comment on the project's progress and significant accomplishments to date.

Reviewer 1:

The reviewer noted that it seems that a lot of modules have been developed and workshops delivered but it was not possible to evaluate the quality of the products because metrics on the number of people and key audiences reached were not presented.

Reviewer 2:

The reviewer commented that the team has identified training partners within the Clean Cities coalitions and provided documentation that indicates "scheduled" or "on-target" for these efforts; however, additional clarity on what these terms mean would be helpful. The reviewer noted that content creation must have taken a lot of effort and time, and the opportunity still exists to meet the targets.

Reviewer 3:

The reviewer stated that for BP 2, of the 15 planned EV Community Preparedness Assessment Workshops, 10 had been hosted, with five scheduled to be done, and indicated that this shows adequate and consistent progress and gives every indication that the project is on track to meet its objectives in a timely manner.

Reviewer 4:

The reviewer found that this project has more than achieved its goals.

Question 4: Please comment on the level of collaboration within the project team and the degree to which the project team has identified and leveraged the proper connections to achieve its project goals.

Reviewer 1:

The reviewer stated that collaboration seems solid; however, there does not seem to be any intention to ensure a long-term business model to provide this training/these workshops in an ongoing way. The reviewer noted that the presenter basically said, "it will be there if Clean Cities want to use it," but the reviewer found that this approach seems to ensure it will slowly become less relevant and useful.

Reviewer 2:

The reviewer commented that leveraging Clean Cities coalitions is a smart way to reach intended audiences and noted that the team identified the need to leverage expertise from a diverse number of stakeholders, ranging from first responders to utilities, insurance companies, tow truck operators and others. The reviewer noted that the knowledge gaps that stakeholders have will be a barrier to EV adoption and this project provided an innovative approach to bringing key actors to the table and creating training/knowledge to inform communities.

Reviewer 3:

The reviewer stated that the structure of having three Clean Cities coalitions partnering with the NFPA as main collaborators will make the partnership nimbler and will facilitate better communication within the project leadership group. The reviewer added that recruiting 30 coalitions to deliver the workshops is also smart and allows those coalitions to leverage local knowledge, strengthen ties in their communities and foster greater stakeholder engagement. The reviewer noted one critical assumption made that, "beyond the grant period, we believe these workshops will begin a cascading effect, so that every Clean Cities Coalition around the U.S. will be able to implement such workshops in their own communities." The reviewer found that this statement articulates a nice hope for future effect and expressed hope that the training materials will be available through the "Ready for EVs" website, to help achieve this.

Reviewer 4:

The reviewer commented that this project drew upon the strengths of many different members of the project team.

Question 5: Please provide comment on the contribution of this project to energy equity and environmental justice by ensuring the project benefits underserved and overburdened communities and does not cause increased burdens to these communities.

Reviewer 1:

The reviewer commented that there we no attempts to focus this training or outreach on communities defined by the Justice40 Initiative/historically underserved communities, or to ensure the content centers those communities and their needs.

Reviewer 2:

The reviewer stated that perhaps the benefit to underserved communities is implied, but in reviewing documentation, this element is not fully discussed.

Reviewer 3:

The reviewer noted that the project plans to hold workshops nationwide, with 34 workshops in communities under 100,000 population and 41 in cities above 100,000 population. The reviewer added that the presentation did not specifically mention targeting disadvantaged or under-served areas, but the project approach did state that NFPA is: "developing EV educational offerings that increase community preparedness planning and collaboration among EV ecosystem stakeholders regardless of the community's socio-economic status," and "to ensure these materials are accessible to all and do not create undue burden."

Reviewer 4:

The reviewer observed that this training is provided for free, and they have a very successful marketing strategy, meaning that this is available to anyone, as long as they know it exists. The reviewer suggested that more targeted marketing to emergency responders in overburdened communities would be something to consider going forward.

Presentation Number: TI134
Presentation Title: Delivering Clean Air in Denver: Propane Truck and Infrastructure in Mail Delivery Application
Principal Investigator: Bonnie Trowbridge (Drive Clean Colorado)

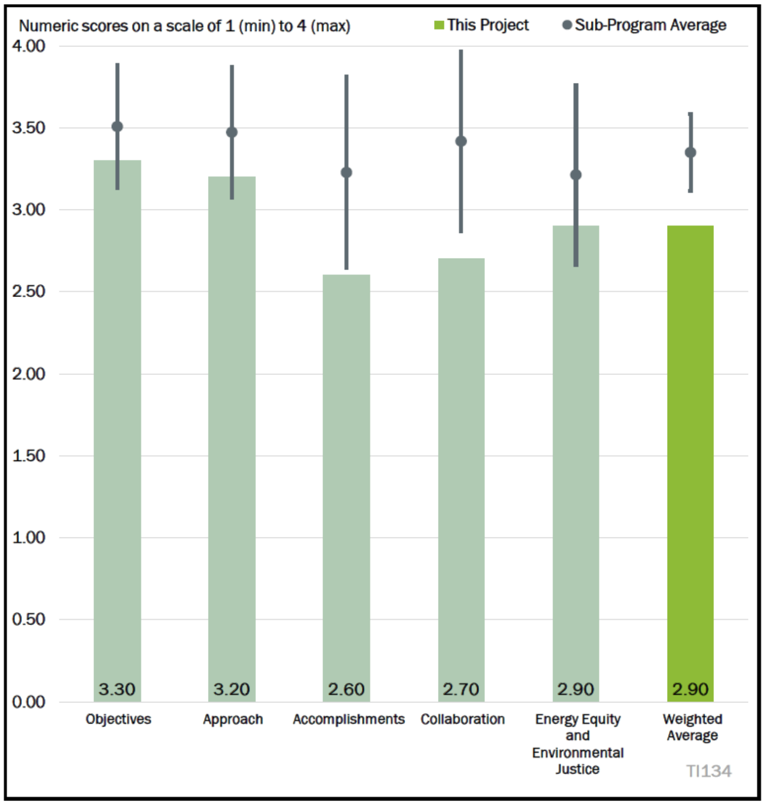

Figure 6-9 - Presentation Number: TI134 Presentation Title: Delivering Clean Air in Denver: Propane Truck and Infrastructure in Mail Delivery Application Principal Investigator: Bonnie Trowbridge (Drive Clean Colorado)

Presenter

Bonnie Trowbridge, Drive Clean Colorado

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Please provide comments on this project's degree of support for the overall Technology Integration (TI) objectives of improving fuel diversity, increasing local resiliency, and reducing greenhouse gas emissions through increasing alternative fuel use and transportation efficiency.

Reviewer 1:

The reviewer noted that the project objectives are straightforward and clearly presented, detailing a proof-of-concept for the use of propane-powered fleet vehicles. The reviewer added that the project aims to demonstrate a real-world example that can shed light on the costs, operational issues, and performance of propane vehicles so that they can be more easily adopted in other contexts.

Reviewer 2:

The reviewer observed that while many Clean Cities coalitions are aggressively promoting EVs, Denver's Drive Clean Colorado has kept an "all of the above" focus of fuel diversity by creating a project designed for the promotion of propane fueled transportation. The reviewer noted that the data gathered from this project will educate fleet managers on the ins and outs of transitioning to this fuel, (hopefully dispelling fears about the fuel). The reviewer commented that propane vehicles are the smart option for many fleets looking for gas and diesel alternatives, (depending on the fleet's location and resources). The reviewer suggested extending this project's timeline, as the data acquired has the potential to make a significant impact in the promotion of this fuel.

Reviewer 3:

The reviewer noted that this effort examines the viability of propane vehicles for mail delivery, and if successful, this would provide a basis for the U.S. Postal Service (USPS) to adopt these vehicles into its fleet. The reviewer stated that, if successful, the project could improve local fuel diversity and resiliency. The reviewer added that propane vehicles do have air pollutant emissions benefits, but their benefit in reducing GHG emissions is reliant on using renewable propane.

Reviewer 4:

The reviewer stated that the project seems well-aligned with VTO priorities, demonstrating clean transportation options in an important application/sector, and added that it was also focused on a recent technology with little in-use data.

Reviewer 5:

The reviewer stated that the objective of collecting real-world operational cost data is critical to providing fleets and consumers with information they need to make decisions regarding purchase of alternative fuel vehicles, and for that reason, the reviewer rated this project very highly.

Question 2: Please comment on this project's approach for integrating advanced transportation technologies and practices to solve real-world challenges.

Reviewer 1:

The reviewer commented that the project approach is clear, stating that fleet support, data collection, and education and outreach are the three main prongs of the effort.

Reviewer 2:

The reviewer found the approach to be straightforward: create a project with strong, fully dedicated partners; deploy vehicles; gather data; and share the success through targeted outreach. The reviewer noted that propane use has proven to reduce particulates compared to diesel, and that promotion of this fuel in fleets, particularly high use fleets like USPS, will improve air quality and promote energy independence. The reviewer added that conversion to a propane fleet is considerably less costly than converting to EVs.

Reviewer 3:

The reviewer noted that the project involved the purchase and installation of propane trucks and refueling infrastructure; in addition, data is to be collected on the performance, while education and outreach were also provided. The reviewer applauded the approach of having webinars and participating in the Work Truck Show. The reviewer commented that, while it is useful to present the results to the postal contractor association, a major weakness in the project is the lack of support from USPS or the postal contractor association as a project partner.

Reviewer 4:

The reviewer noted that a key element of the approach was working with the high-daily-use postal contractor fleets to lead to market transformation, and the project included specific elements addressing environmental benefits. The reviewer commented that it was a straightforward approach—buy vehicles, put them into the fleets, collect data, and do outreach and education.

Reviewer 5:

The reviewer commented that putting vehicles in actual use and collecting data is critical to providing realistic information, so the approach is excellent for that reason. The reviewer would have rated the project higher if the emissions data was based on actual in-use monitoring and provided comparison to conventional fuels. The reviewer recognized, however, that in-use emissions testing is expensive.

Question 3: Please comment on the project's progress and significant accomplishments to date.

Reviewer 1:

The reviewer noted that, given that this is a three-year project in its final year, the team has successfully completed a large proportion of the scope, at this point, and added that the team plans to have discussions with the postal contractor association to present their findings and spur discussions of feasibility for incorporating this technology into the postal fleet.

Reviewer 2:

The reviewer noted that, at 85% complete, the project is on track, and pandemic related delays—including staff shortages and infrastructure permitting issues—could not have been anticipated when the proposal was submitted. The reviewer added that, with months to go, the project is up and running and data is coming in; hats off to the project team for hanging in there with the delays and working to complete the tasks that could be completed given the circumstances. The reviewer stated that the delays and staff shortages are understandable due to COVID; however, that all vehicles could not get up and running until November—after being delivered in August—indicates more needs to be done to work the kinks out of propane vehicles, and added that the drained batteries and the service parties not committed to being responsible for the fix are big issues that need to be resolved. The reviewer stated that all service parties—dealerships, upfitters, fuel distributors—must adhere to clear areas of responsibility when a problem arises; fleet managers will not tolerate the back and forth and will not consider adding more vehicles if it is problematic.

Reviewer 3:

The reviewer observed that the project has faced major setbacks along the way including a delay in delivery of trucks, and permitting delays for the refueling infrastructure, which have delayed the webinars and outreach. The reviewer noted that, once the trucks entered operation, they faced frequent downtime due to service and repairs and the lack of service staff to address them. In addition, the reviewer noted that project partners were blaming each other for the issues with vehicle downtime, rather than working together to get them solved.

Reviewer 4:

The reviewer noted that all five vehicles are up and running in the fleets—a definite accomplishment given supply chain delay impacts on other projects; it took 1-1/2 years to get the vehicles. The reviewer added that the project team seems to have overcome delay issues along the way, all equipment has been in operation since late 2022, and the project team has been in communication with a number of fleets who have shown interest in the technology. The reviewer commented that they continue to deal with issues with maintenance in particular, but that is not unusual, and that has impacted the schedule for data collection. As a result, the project has insufficient results to review at this time.

Reviewer 5:

The reviewer observed that the presenter revealed that the project has experienced setbacks related to data collection because of problems with the vehicles; these problems appear unrelated to the alternative fuel but related to implementation of the projects and within the control of project sponsors and participants.

Question 4: Please comment on the level of collaboration within the project team and the degree to which the project team has identified and leveraged the proper connections to achieve its project goals.

Reviewer 1:

The reviewer noted that there are regular meetings with project partners but more information on partners could have been provided.

Reviewer 2:

The reviewer commented that the lead did an excellent job of choosing the right partners for this project, including NREL for top notch data collating. Everyone was committed and hung in there when delays and problems popped up.

Reviewer 3:

The reviewer observed that once the trucks entered operation, they faced frequent downtime due to service and repairs and the lack of service staff to address them. In addition, project partners were blaming each other for the issues with these vehicles' downtime, rather than working together to get them solved.

Reviewer 4:

The reviewer commented that it seems like they assembled a team with all the necessary parties and have seen a high degree of interaction among the partners.

Reviewer 5:

The reviewer stated that the presenter acknowledged that problems with the vehicles have not been satisfactorily addressed because project participants have not taken responsibility for the issues and added that it is noteworthy that the issues are not related to the alternative fuel components.

Question 5: Please provide comment on the contribution of this project to energy equity and environmental justice by ensuring the project benefits underserved and overburdened communities and does not cause increased burdens to these communities.

Reviewer 1:

The reviewer commented that more details on impacts/benefits to DACs would be helpful.

Reviewer 2:

The reviewer noted that operating propane fueled vehicles will reduce particulates in the areas used. The reviewer observed that Denver is facing a “demotion” in air quality status, and the vehicles will be operating in areas that include “disproportionately impacted communities.”

Reviewer 3:

The reviewer observed that these trucks will have lower air pollutant emissions than their diesel counterparts, and as these vehicles are operating in an area with poor air quality, this will provide some benefits to overburdened communities in the area.

Reviewer 4:

The reviewer commented that the project team and approach specifically targeted operation in disadvantaged and environmentally compromised communities.

Reviewer 5:

The reviewer expressed the view that good is probably as high as you can rate these demonstration projects because the direct benefits to affected communities will come later when more fleets and business deploy the technologies based on lessons learned and analysis provided by the demonstration.

Presentation Number: TI135
Presentation Title: Advancing Climate and Innovation Goals of Memphis and Shelby County: Electrification of Key Fleet Vehicles to Capture Cost Savings and Climate Benefits
Principal Investigator: Leigh Huffman (Shelby County)

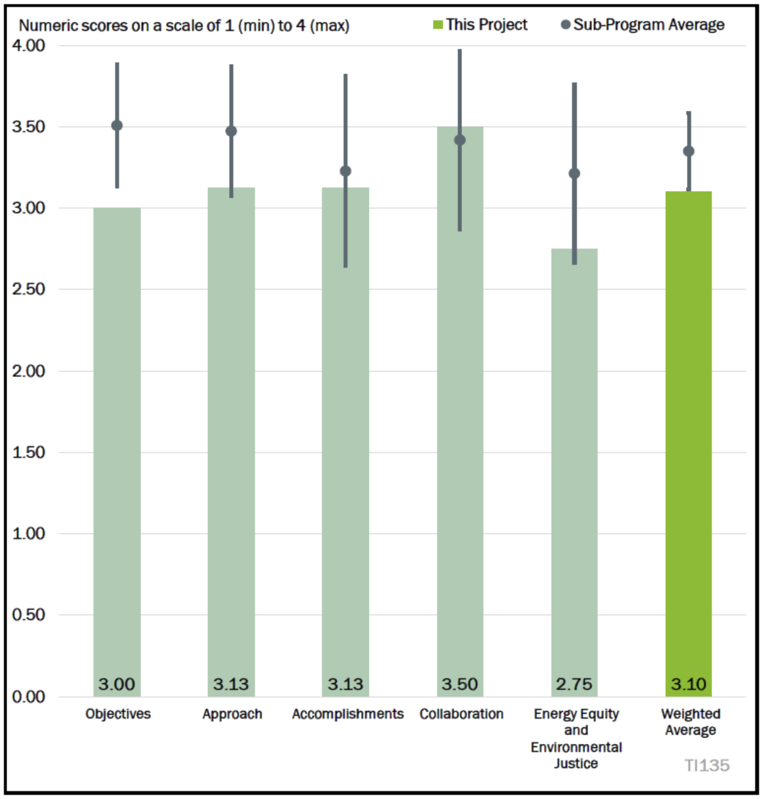

Figure 6-10 - Presentation Number: TI135 Presentation Title: Advancing Climate and Innovation Goals of Memphis and Shelby County: Electrification of Key Fleet Vehicles to Capture Cost Savings and Climate Benefits Principal Investigator: Leigh Huffman (Shelby County)

Presenter

Leigh Huffman, Shelby County

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Please provide comments on this project's degree of support for the overall Technology Integration (TI) objectives of improving fuel diversity, increasing local resiliency, and reducing greenhouse gas emissions through increasing alternative fuel use and transportation efficiency.

Reviewer 1:

The reviewer noted that the County seeks to electrify its fleet as much as possible, with this pilot program being the first step, and though the impact is small here, this project supports all the TI objectives listed above.

Reviewer 2:

The reviewer commented that this is a great example of support for TI; a pilot at the local level where next-generation technology can be difficult to introduce.

Reviewer 3:

The reviewer stated that while the overall objective is appropriate for VTO (initial EVs in a fleet to provide data for future decision-making and adoption), the scope is relatively small regarding potential influence and thus overall impact. The reviewer added that the project is primarily focused on just the Shelby County fleet, and no external outreach is planned, such as to other fleets in the region.

Reviewer 4:

The reviewer noted that there was a good set of objectives for a small-scale deployment project.

Question 2: Please comment on this project's approach for integrating advanced transportation technologies and practices to solve real-world challenges.

Reviewer 1:

The reviewer commented that the project approach is simple and effective: procure vehicles, install charging stations, deploy vehicles while increasing number of EVSE installations, and execute a robust outreach and education campaign. The reviewer noted that Shelby is one of thousands of counties working on increasing transportation efficiency in their fleets and added that if all areas of government—cities, counties, states—did the same it would make a significant impact on transportation efficiency and air quality.

Reviewer 2:

The reviewer stated that a medium-duty (MD) all-electric truck is a good application focus for this area and will be helpful for local stakeholders to better understand the technology.

Reviewer 3:

The reviewer opined that the approach seems fine as far as the fleet demonstration and training is concerned, although it would have been good to include some element of outreach and education beyond the Shelby County fleet to increase the project's impact.

Reviewer 4:

The reviewer found the plan for testing vehicles and sharing results to be a solid one.

Question 3: Please comment on the project's progress and significant accomplishments to date.

Reviewer 1:

The reviewer observed that there have been issues with procurement and so far, just one vehicle has been delivered and is in operation, although this was not the vehicle the project originally sought to acquire (which was to be a Ford F650 dump truck). A Class 6 truck was received and put in use but has a design issue (not enough clearance). The reviewer commented that the lead has done an excellent job rolling with the punches and modifying the plan and the project has received a no cost extension to 2025. The reviewer observed that they are currently awaiting four more vehicles to deploy and to be ready for this, the lead is actively planning more charging station installations. The county also delivered an emergency plan to first responders.

Reviewer 2:

The reviewer stated that while more work will be done for procurement and installs, it is good to see a truck procured and infrastructure moving to deployment.

Reviewer 3:

The reviewer noted that the first vehicle has arrived and begun operation, which is a real accomplishment; that even included a procurement change from a converted vehicle to an OEM EV, though they did find out that the replacement truck had lower ground clearance than required. The reviewer stated that they do appear behind on EVSE installation, though they did research additional sites for L2 charging, and added that the other four vehicles have been ordered. The reviewer observed that they were trying to get on the list for Ford Lightnings but may go back to Ford Mustang Mach-E vehicles or go out for bid.

Reviewer 4:

The reviewer commented that there is still work to do to deploy infrastructure and take delivery of vehicles, adding that global supply chain issues have affected vehicle cost and delivery timelines.

Question 4: Please comment on the level of collaboration within the project team and the degree to which the project team has identified and leveraged the proper connections to achieve its project goals.

Reviewer 1:

The reviewer noted that the project has included the following partners: local utility, government, a dealership, an OEM and a Clean Cities coalition, and that all appear to work well together. The reviewer observed that although the Ford dealership cannot promise what vehicles will arrive and when that will happen, that appears to be a nationwide availability issue with Ford Lightnings and Mustang Mach-Es.

Reviewer 2:

The reviewer stated that this is a complex partnership project, and the county has done well working with a broad gathering of supporting partners.

Reviewer 3:

The reviewer noted that the team includes the partners needed for the fleet demonstration—the fleet, utility, OEMs, and the local Clean Cities coalition, and added that it would have been good to have someone tasked with spreading the word to expand the impacts beyond the fleet. The reviewer observed that the agency representatives within the county have been participating in monthly meetings, and the agencies involved have grown.

Reviewer 4:

The reviewer commented on the great set of team members to help advise deployment and share lessons learned with other fleets in the region.

Question 5: Please provide comment on the contribution of this project to energy equity and environmental justice by ensuring the project benefits underserved and overburdened communities and does not cause increased burdens to these communities.

Reviewer 1:

The reviewer noted that this project's focus is to work to electrify the county government's fleet, which shows a commitment to the improvement of air quality in the region.

Reviewer 2:

The reviewer stated that while the analysis proposed is helpful, the future impact on EEEJ would be good to have.

Reviewer 3:

The reviewer observed that the project only addresses general air quality and emissions reductions, with no particular indication that DACs would see benefits.

Reviewer 4:

The reviewer stated that there are many EJ identified communities in the project area and expressed the view that the project could do more to target vehicle operations in these areas.

Presentation Number: TI136
Presentation Title: Zero Emission Freight Future
Principal Investigator: Tim Cho (Clean Fuels Ohio)

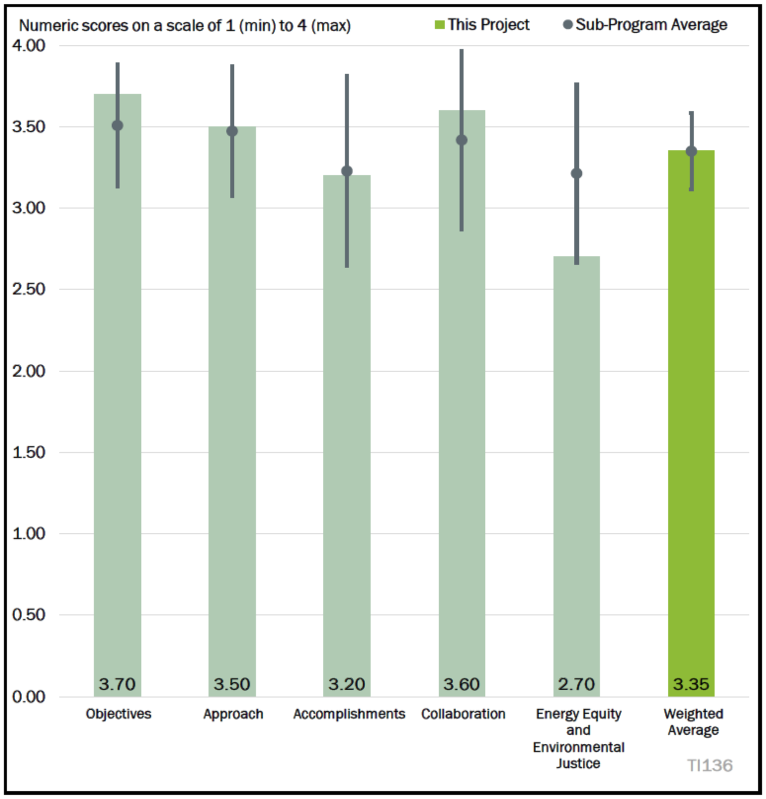

Figure 6-11 - Presentation Number: TI136 Presentation Title: Zero Emission Freight Future Principal Investigator: Tim Cho (Clean Fuels Ohio)

Presenter

Tim Cho, Clean Fuels Ohio

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Please provide comments on this project's degree of support for the overall Technology Integration (TI) objectives of improving fuel diversity, increasing local resiliency, and reducing greenhouse gas emissions through increasing alternative fuel use and transportation efficiency.

Reviewer 1:

The reviewer commented that although the project is designed around the deployment of just three Class 4-8 vehicles, the analyses from data gathered on vehicle operations throughout Ohio will assist fleet decision-making. The reviewer further observed that these vehicles are now part of highly visible companies (PITT OHIO, Bimbo Bakery and hopefully City of Columbus), operating in key areas—which will further promote awareness of EVs. The reviewer found that this project supports all of the TI objectives above.

Reviewer 2:

The reviewer found the plan to be very good and commented that it was unfortunate that the original supplier of the waste hauling truck did not supply it in time.

Reviewer 3:

The reviewer noted that the objectives are to deploy MD/HD EVs by highly visible fleets in key vehicle platforms, improve MD/HD EV datalogging and reporting capabilities, prove the operational and financial case for EVs, leading to Class 4–8 adoption in various applications, and address critical gaps in MD/HD vehicle data and analysis to enhance fleet decision-making and EV adoption. By reducing GHG emissions and promoting transportation electrification for further GHG reduction, the reviewer found that the project meets the DOE goals.

Reviewer 4:

The reviewer observed that the project is focused on several applications that have seen lower EV adoption rates and that these are also several high-visibility applications. The reviewer commented that, overall, this project has been designed to move zero emission vehicles forward, a key goal for VTO efforts.

Reviewer 5:

The reviewer stated that telematic data retrieval and analysis is the key to answering this question and based on the PowerPoint slides and the oral presentation the project team is on track to accomplish its milestones.

Question 2: Please comment on this project's approach for integrating advanced transportation technologies and practices to solve real-world challenges.

Reviewer 1:

The reviewer observed that the project approach is to install EVSE, acquire three vehicles and deploy them to gather data during operation, and added that the project will identify areas of improvement in telematics and develop an MD/HD EV analysis model with the assistance of Sawatch Labs. The reviewer noted that in the remaining months the team plans to continue with data gathering and assemble documentation and findings for replication. The reviewer recommended a no cost time extension to gather enough data to support analyses.

Reviewer 2:

The reviewer stated that truck data information appears on track but added that an explanation of the analysis tool would have been helpful. The reviewer expressed surprised that there was no discussion of the truck charging process and any challenges.

Reviewer 3:

The reviewer found the approach to be solid, with three phases, and summarized the approach as follows: overall program development; demonstration, analysis, and tool creation; and presentation of findings and dissemination. The reviewer detailed the overall program development as developing a data collection and analysis plan, convening a project advisory committee, developing a fleet demonstration deployment plan, creating design and engineering plans, creating specifications for EV and EVSE, and purchasing and deploying EVs and EVSE. The reviewer indicated that the demonstration, analysis, and tool creation is designed to identify data gaps for MD/HD telematics improvements and stated that the OEMs will gather and analyze data on EV deployments to date, gather analysis model data and begin developing models. The presentation of findings and dissemination will include a completion plan for replication resources. The team will seek feedback on replication resources and disseminate final replication resources and tools.

Reviewer 4:

The reviewer indicated that the project approach was solid, focusing on several key applications for EVs and then developing models and collecting data to show how they performed.

Reviewer 5:

The reviewer indicated that the team appears to have the right approach to integrating advanced transportation technology and practices. The reviewer added that the final answer will not be known until the project is over and the data is evaluated.

Question 3: Please comment on the project's progress and significant accomplishments to date.

Reviewer 1:

The reviewer observed that even though lack of MD/HD EV availability is an issue for many similar projects, this project was able to acquire two of the three trucks and use data from PITTS' other electric truck. The reviewer indicated that the team needs more time than is left to gather data on the step van and figure out if the refuse truck purchase can happen. As such, the reviewer suggested requesting a time extension.

Reviewer 2:

The reviewer indicated that progress appears satisfactory and suggested that a timeline plan of the milestones would be helpful.

Reviewer 3:

The reviewer stated that project accomplishments include progress on data collection and analysis, such as collecting one year of vehicle telemetry, operations, and fuel usage data from a Class 7 EV Straight Truck (May 2022–April 2023). The reviewer noted that approximately 25% of the energy being used is being offset by regenerative energy captured throughout the course of the driver's day-to-day routes and stops, and the truck is averaging 1.12 kWh/mile with a 28-mpg efficiency using a 264 kWh battery pack (approximately a 200-mile range). The reviewer noted that the project team has designed engineering plans for fleet deployment, completed specifications, and purchased and deployed EVs and EVSE. The reviewer stated that it does not look like the refuse truck deployment will be in the scope of the project.

Reviewer 4:

The reviewer noted that two of the three vehicles are now in operation, including one very recently that had been delayed, but the third vehicle is a significant issue: the OEM cancelled the order, and the team is now having to request and evaluate bids from other refuse truck manufacturers. The reviewer observed that this is not unusual among the deployment projects, as supply chain issues continue. The reviewer stated that the team collected the data that they could, and right now, it is unclear if they will be able to get a refuse truck by the end of the year; if they can, then they might try to get 60–90 days of data, possibly through an extension.

Reviewer 5:

The reviewer observed that many of the projects seem to be behind schedule due to certain vehicles like the EV refuse trucks not being available, and late delivery of the Bimbo Bakery EV truck, and added that this is to be expected due to the availability of specialized EVs; the rest of the project appears to be on schedule.

Question 4: Please comment on the level of collaboration within the project team and the degree to which the project team has identified and leveraged the proper connections to achieve its project goals.

Reviewer 1:

The reviewer commended the team lead on making outstanding choices in partners for this project, including OEMs, a software analytics firm and highly visible, enthusiastic fleets. The reviewer noted that it is unfortunate that the OEM rescinded the purchase order on the refuse truck and expressed optimism that this project is able to acquire another (or acceptable replacement) to gather data on the Class 8 refuse truck.

Reviewer 2:

The reviewer commended the team on doing a good job.

Reviewer 3:

The reviewer commented that the team is strong with the exception of Lion Electric, which withdrew from the project. The reviewer noted that the main problem that has affected the project up to this point has been the long lead/delivery times of specific MD/HD vehicle models (specifically the refuse truck). The third fleet partner had to discontinue their vendor-client relationship with the original OEM and is going through another bidding process to supply a Class 8 EV Refuse Truck for this project. The reviewer stated that the rest of the team is strong with project lead Clean Fuels Ohio; fleet deployment partners, PITT OHIO, City of Columbus, and Bimbo Bakeries; technical partner, Sawatch Labs; and OEM partners, Volvo and Motiv Power Systems, all industry professionals.

Reviewer 4:

The reviewer observed that the project included all the key types of partners on the team, which was very well organized and included the fleets and the OEMs from the beginning. The reviewer stated that one OEM turned out to be a problem for delivery, but the team has worked to pull in other OEMs to try to fill the hole for the refuse truck, and the fleets seem highly engaged.

Reviewer 5:

The reviewer stated that collaboration and coordination appear to be within the grant requirements, but late delivery of two of three of the vehicles has meant not all the expected performance data at this point in the project is available.

Question 5: Please provide comment on the contribution of this project to energy equity and environmental justice by ensuring the project benefits underserved and overburdened communities and does not cause increased burdens to these communities.

Reviewer 1:

The reviewer observed that the project plans to use the Greenlink Equity Map (GEM) tool to identify areas of disparities in pollution in the three demonstration cities and noted that reduction of carbon emissions in the operations of MD and HD EVs will have a significant impact once more of these vehicles are acquired by fleets.

Reviewer 2:

The reviewer noted some discussion on EJ issues but no real partner or planned activity for outreach.

Reviewer 3:

The reviewer noted that the goal was to utilize the GEM tool to identify disparities in energy burden, climate risks, and pollution impacts for these three MD/HD EV pilot demonstration cities. The reviewer stated that the project reduces carbon emissions in communities overburdened with environmental pollution and showcases the financial feasibility of electrifying fleets for both private and public sector benefiting community members. The reviewer commented that the PITT OHIO project is improving air quality from freight ground services and supply chain solutions around northeast Ohio, while the Bimbo Bakery project is reducing direct tailpipe emissions in communities around the Dayton area. The reviewer observed that the City of Columbus did not deploy the planned refuse truck, although deployment would align with Columbus Climate Action Plan's Environmental Justice and sustainability goals.

Reviewer 4:

The reviewer stated that use of the vehicles is anticipated to provide benefits to overburdened communities, and the project's emphasis on exploring the financial feasibility of zero emission freight technology should lead to greater penetration in this sector.

Reviewer 5:

The reviewer commented that, based on the type of vehicles deployed and to be deployed, it appears EEEJ justice requirements of the grant will be met; however, not much is said about this area in the slides or presentation.

Presentation Number: TI137
Presentation Title: Cold-Weather Operation, Observation and Learning Electric Vehicles
Principal Investigator: Lisa Thurstin (American Lung Association)

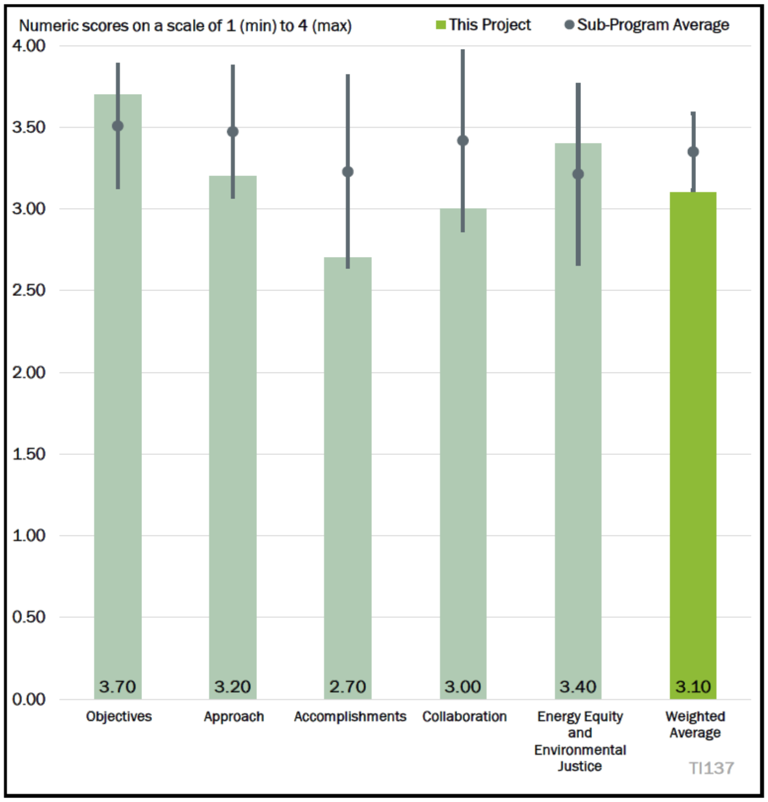

Figure 6-12 - Presentation Number: TI137 Presentation Title: Cold-Weather Operation, Observation and Learning Electric Vehicles Principal Investigator: Lisa Thurstin (American Lung Association)

Presenter

Lisa Thurstin, American Lung Association

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Please provide comments on this project's degree of support for the overall Technology Integration (TI) objectives of improving fuel diversity, increasing local resiliency, and reducing greenhouse gas emissions through increasing alternative fuel use and transportation efficiency.

Reviewer 1:

The reviewer stated that understanding how ambient temperature affects batteries is imperative to the promotion of EVs, and this project's location—Minnesota—allows for data to be collected in both very cold and very warm temperature situations. The reviewer observed that information gathered may help R&D improve battery performance and longevity, particularly in extreme cold and warm climates. The reviewer suggests the project end date be extended so the team can collect enough useful data on all vehicles.

Reviewer 2:

The reviewer commented that this effort examines the viability of HD EVs in a cold climate, and, if successful, the project could improve local fuel diversity and resiliency through the use of EVs. The reviewer noted that other locations with cold-weather operations would benefit from the lessons learned from this project, adding that EVs can have significant GHG emissions benefits, but quantity depends on the grid mix serving these vehicles.

Reviewer 3:

The reviewer noted that the project is focused on a key area of need—cold (and hot) weather performance data for EVs, which is important to ensure EV technology readiness in difficult operating environments, expanding use of a technology of great interest to VTO.

Reviewer 4:

The reviewer stated that cold weather operations are a noted barrier to vehicle electrification, and data collected as part of this project will be useful.

Reviewer 5:

The reviewer observed that there is only one fuel (electricity) in the project and stated that fuel diversity is a moot point. The reviewer added that, as far as GHG and transportation efficiency, there is more vehicle usage data to be collected; key data that should be collected and analyzed once the project is completed should lead to resiliency improvement in EV cold weather operations.

Question 2: Please comment on this project's approach for integrating advanced transportation technologies and practices to solve real-world challenges.

Reviewer 1:

The reviewer found the project to have clear steps to initiate—gather support partners and fleet participants, install EVSE, deploy and operate vehicles, gather data and share successes, and lessons learned—and noted that the project has a significant training and outreach component. The reviewer stated that the keys to increased EV deployment in northern and southern regions include eliminating the high cost of the vehicles and reducing any doubt about battery performance. The reviewer added that vehicles sit in very cold garages during the winter in northern regions; when driven, the heaters are blasting. In southern regions vehicles sit out in parking lots exacerbating the 110° heat in summer, and when driven the AC is on non-stop, and observing how batteries react to these stressors will be very helpful in understanding the next steps to battery improvement. The reviewer noted that the overview indicates one of the barriers to be addressed is "cost of medium and heavy-duty EVs" and it was not clear how that would be integrated in this project. The reviewer surmised that it would be accomplished through data that would support lower total cost of ownership (TCO) and that would be shared in outreach and promotion of EVs.

Reviewer 2:

The reviewer noted that the project's goal is to deploy four HD EVs and charging infrastructure in three community fleets in the Minneapolis/St. Paul metro area and analyze cold weather impacts to their functionality and provide lessons learned, and one of the key parts of this project is having the local utility work on the make-ready issues related to charging infrastructure. The reviewer stated that it is unclear what the project approach is to data collection and how they will analyze different vehicle types; it was stated that miles traveled, electricity consumption and maintenance data were being collected at a high level but due to challenges with the telematics data they have not collected detailed information yet. The reviewer commented that it would be useful for the project to spend some time working on the data collection plan and what they can or cannot collect based on what the fleets' telematics/data collection efforts can provide.

Reviewer 3:

The reviewer found that the approach is solid and makes sense—deploy HD EVs and charging systems in the Minnesota climate and analyze the performance. The reviewer added that the approach was solid enough that when a fleet backed out, they were able adjust to evaluate 12 fleets for a possible replacement.

Reviewer 4:

The reviewer observed that the project team had to re-run the request for proposals for fleets as one original partner on the project dropped out.

Reviewer 5:

The reviewer noted that the project uses real world diverse fleets to demonstrate and evaluate unique cold weather operational requirements and added that it is understandable that vehicle availability would be an issue, especially in the EV arena.

Question 3: Please comment on the project's progress and significant accomplishments to date.

Reviewer 1:

The reviewer observed that the school bus has been in operation for approximately 18 months and demonstrations and outreach have occurred. The reviewer added that the project lead could not have anticipated the pandemic related issues that have caused delays in the deployment of the vehicles (no vehicles, no data), or the problems interpreting the school bus's data. The reviewer noted that at this time only one of the four vehicles are operating; one fleet participant withdrew, and the data on the school bus came through garbled. The reviewer commented that according to the presenter there is poor communication between Battle Motors and the OEM on the refuse truck that was ordered, and they may have to scrap that plan, but the Peterbilts are receiving the boxes and will be operating and collecting data soon. The reviewer suggests that the lead request a significant time extension on this project so enough data will be gathered to complete the objectives.

Reviewer 2:

The reviewer observed that the project has had significant delays; in addition, one of the fleets that was planning to participate dropped out and no other fleet has replaced it (presenter said it would be unlikely they will find anyone). The reviewer noted that one of the fleets received its vehicle (a school bus) and installed L2 charging, and that vehicle has been on the road for 1.5 years, but the data collection effort has had significant problems. The reviewer noted that it was mentioned that project partner CTE for data analysis wase just seeing garbled data from the telematics, and they plan to go straight to the telematics company, Geotab, to get the data. The reviewer observed that the University of Minnesota's two vehicles were being upfitted, while the Eureka Recycling refuse truck has been on order for 2 years and they are not sure when it will be delivered. The reviewer noted that the presenter stated that there has been poor communication between Battle Motors and the OEM on this refuse truck. As a main goal is to examine cold-weather operation of these HD EVs, the reviewer commented that these major delays have seriously impacted this project's ability to do so.

Reviewer 3:

The reviewer commented that there have been issues obtaining several of the vehicles as well as with the data collection systems, and only one vehicle is in operation at this time. The reviewer noted that the project team claims to be about 50% complete, although the project is scheduled to be completed in only 6 months (by the end of December 2023). The reviewer observed that there have been problems with a vehicle supplier for the recycling truck, and that the team may have to take an alternative path. The reviewer stated that, to the team's credit, they have done a lot of outreach and education.

Reviewer 4:

The reviewer noted that global supply chain challenges have affected deployment of vehicles, and this is outside the hands of the project team.

Reviewer 5:

The reviewer stated that it appears the project is proceeding in line with the proposed timetable, regardless of vehicle availability.

Question 4: Please comment on the level of collaboration within the project team and the degree to which the project team has identified and leveraged the proper connections to achieve its project goals.

Reviewer 1:

The reviewer observed that team dynamics are lead—support partners—participating fleets, giving the feel of a top-down team model (vs. a lateral team model). During the presentation, the reviewer got the impression that the three participating fleets are enthusiastic.

Reviewer 2:

The reviewer commented that it looks like the project had good support from Xcel Energy for installing one of the chargers; however, one of the project partners dropped out and it does not seem as if there will be a replacement. The reviewer added that there have been significant delays in obtaining the vehicles, which can be attributed to the supply chain. The reviewer noted that the Eureka Recycling refuse truck has been on order for 2 years and there has been poor communication between Battle Motors and the OEM on this refuse truck about when this vehicle will be delivered. The reviewer added that the project partners have had significant issues working together on data collection from the telematics systems.

Reviewer 3:

The reviewer commented that the original roster of partners made a lot of sense, although some have dropped out along the way. The reviewer noted that the project team has worked to interact with the remaining partners and interviewed 12 potential replacement fleets, and there has also been a lot of technical support provided.

Reviewer 4:

The reviewer noted that the team includes a Clean Cities Coalition, fleets, utilities, and vehicle manufacturers.

Reviewer 5:

The reviewer stated that, according to the presentation, the project team was working together with a high degree of collaboration and coordination and added that it also appeared that the project team selection has led to a coordinated, properly leveraged team effort.

Question 5: Please provide comment on the contribution of this project to energy equity and environmental justice by ensuring the project benefits underserved and overburdened communities and does not cause increased burdens to these communities.

Reviewer 1:

The reviewer noted that, according to the presentation, vehicles will be deployed in “two of three communities of low income.”

Reviewer 2:

The reviewer commented that the project highlights that two out of the three fleets operate in communities of low income. The reviewer stated that the zero emission tailpipe capabilities of EVs will reduce the air pollution emissions of vehicles in these areas. In addition, the reviewer noted that the project plans to develop case studies and demonstrations for underserved communities based on the output of their project.

Reviewer 3:

The reviewer stated that the project has a particular focus on low income/disadvantaged areas, with several of the fleets located in those areas; thus, zero emission technology demonstration in these areas appears to have been a focal point of the approach from the beginning.

Reviewer 4:

The reviewer observed that some vehicles will be deployed in EJ identified communities in the project area and case studies will be created.

Reviewer 5:

The reviewer stated that the project percentage involving EEEJ about equals the percentage allowed for this question.

Presentation Number: TI138
Presentation Title: Demonstrating Electric Shuttles for the New Orleans Region
Principal Investigator: Jordan Stewart (Tulane University)

Presenter

Jordan Stewart, Tulane University

Reviewer Sample Size

A total of four reviewers evaluated this project.

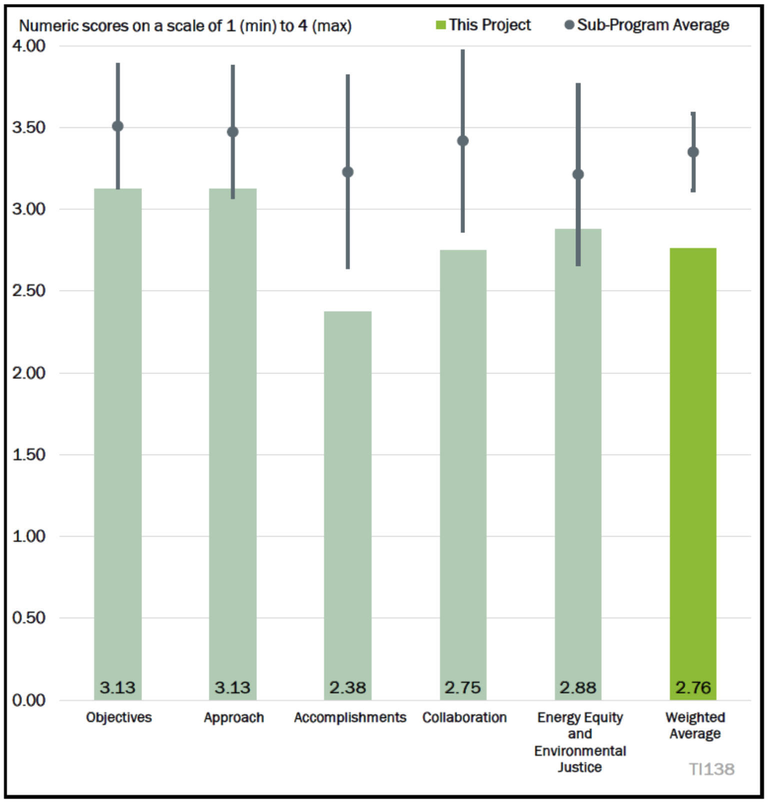

Figure 6-13 - Presentation Number: TI138 Presentation Title: Demonstrating Electric Shuttles for the New Orleans Region Principal Investigator: Jordan Stewart (Tulane University)

Question 1: Please provide comments on this project's degree of support for the overall Technology Integration (TI) objectives of improving fuel diversity, increasing local resiliency, and reducing greenhouse gas emissions through increasing alternative fuel use and transportation efficiency.

Reviewer 1:

The reviewer stated that this project is a great effort that helps increase visibility and potentially adoption of battery-electric vehicles (BEVs) in an area with high marketability and opportunity for application.

Reviewer 2:

The reviewer commented that the two false starts of this project have only served to reinforce how difficult it will be to meet the TI objectives; after two years of work, one fast charger has been installed. The reviewer questioned whether this will this be enough for nine vehicles. The reviewer noted that they are replacing large city buses with small Ford E-Transit vehicles, and speculated that this will significantly impact the route planning, etc.

Reviewer 3:

The reviewer commented that the project is focused on providing a double-bang for the buck—showing EVs in an application sector with fewer EVs adopted to date, and in a sector that reduces vehicle miles traveled (mass transit—local shuttles). The reviewer found the tie to overall VTO goals to be strong.

Reviewer 4:

The reviewer stated that it is a good objective to demonstrate shuttles.

Question 2: Please comment on this project's approach for integrating advanced transportation technologies and practices to solve real-world challenges.

Reviewer 1:

The reviewer found the approach to be solid and building up local qualifications and introducing a cost analysis for EV shuttle applications in this region to be important.

Reviewer 2:

The reviewer indicated that the initial approach was good, but the compromises that have been made may negatively impact the results. The reviewer opined that while they have been waiting for their vehicles to arrive, they should have spent more time in analyzing the metrics and how to improve them. The reviewer stated that real world test results are vitally important.

Reviewer 3:

The reviewer stated that the approach was logically laid out, although they had to make significant changes when they ran into procurement issues on the shuttles. The reviewer noted that they are now in the third version of the procurement process and have increased the order from five to nine shuttles. The reviewer stated that, while the shuttles are smaller than originally planned, this will allow the operator to use them on any of their routes. The reviewer stated that EVSE is in place, though additional EVSE may be installed later.

Reviewer 4:

The reviewer stated that the project plan is reasonable, but vehicle suppliers have been unable to deliver.

Question 3: Please comment on the project's progress and significant accomplishments to date.

Reviewer 1:

The reviewer stated that once the shuttles arrive, this project will have further impact.

Reviewer 2:

The reviewer noted that this project is significantly behind schedule and questioned whether enough research was conducted initially regarding vehicle availability, etc. The reviewer gave the example of Amazon, which has been using BEV cargo vans for several years and asked where they purchased their vehicles.

Reviewer 3:

The reviewer observed that delivery of the buses has not yet occurred, so the principal investigator has requested a no-cost extension to provide the time for operation of the buses and for data collection. The reviewer noted that the project team had to change suppliers twice and is now on their third procurement, and the vehicles are expected to start arriving this summer, with required modifications to the vehicles to take place after initial operation (due to delays in modification equipment). The reviewer noted that installation of the EVSE was delayed somewhat, but that was largely due to a major weather event (Hurricane Ida).

Reviewer 4:

The reviewer stated that manufacturer and supply chain challenges have delayed vehicle delivery, making achieving other goals difficult.

Question 4: Please comment on the level of collaboration within the project team and the degree to which the project team has identified and leveraged the proper connections to achieve its project goals.

Reviewer 1:

The reviewer commented that this is a nice collaboration between a university, the Federal government, industry, and a Clean Cities coalition.

Reviewer 2:

The reviewer stated that if there were good collaboration within the various teams, they probably would have known much sooner about the lack of vehicle availability. The reviewer added that it seems that they knew very little about the local utility "clean" energy, and this detail should have been top of mind for the presentation.

Reviewer 3:

The reviewer commented that the small team seems solid and works together well, under less than terrific circumstances and speculated that it may have helped to have the OEM on the team at the beginning, particularly given that bus suppliers have been the real problem for this project.

Reviewer 4:

The reviewer noted lots of outreach and collaboration even through vehicles have not been deployed yet.

Question 5: Please provide comment on the contribution of this project to energy equity and environmental justice by ensuring the project benefits underserved and overburdened communities and does not cause increased burdens to these communities.

Reviewer 1:

The reviewer stated that while the location of this project will be helpful to the community, it would be good to see more details and efforts for equitable engagement.

Reviewer 2:

The reviewer stated that running BEVs for university transportation will likely benefit the surrounding community; however, it seems that not much thought has gone into the actual metrics of reduced GHG, reduced noise, which underserved communities, etc.

Reviewer 3:

The reviewer noted that the project is focused not only on EVs, but also on EVs for transit, which also addresses vehicle miles traveled reductions. The reviewer noted that they propose that emissions and noise reductions will provide significant benefits for New Orleans' DACs.

Reviewer 4:

The reviewer commented that the project will benefit the local community when deployed, but deployment has been delayed.

Presentation Number: TI139
Presentation Title: Pilot Heavy-Duty Electric Vehicle (EV) Deployment for Municipal Solid Waste Collection
Principal Investigator: Kelli Toth (Municipality of Anchorage)

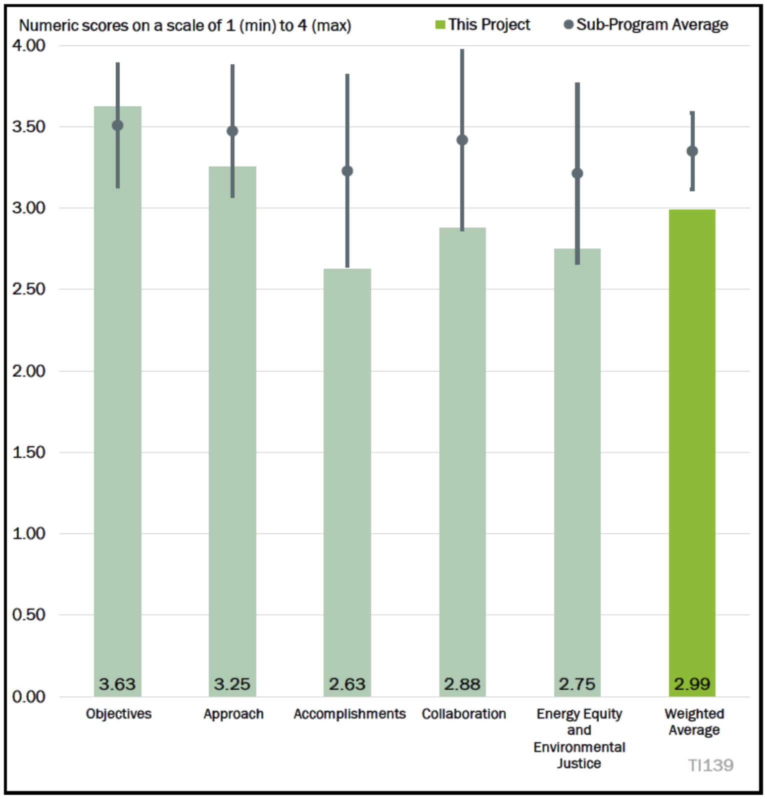

Figure 6-14 - Presentation Number: TI139 Presentation Title: Pilot Heavy-Duty Electric Vehicle (EV) Deployment for Municipal Solid Waste Collection Principal Investigator: Kelli Toth (Municipality of Anchorage)

Presenter

Kelli Toth, Municipality of Anchorage

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Please provide comments on this project's degree of support for the overall Technology Integration (TI) objectives of improving fuel diversity, increasing local resiliency, and reducing greenhouse gas emissions through increasing alternative fuel use and transportation efficiency.

Reviewer 1:

The reviewer stated that the project has an effective goal and a worthy plan for supporting the TI program goals. The reviewer commented that, from the presentation, it was difficult to understand what the plan is for the refuse vehicles and what expectations the project has for carbon reduction, given the baseline duty cycles of the operations. The reviewer noted that fuel cost and efficiencies appear well documented for the Class 6 truck and should greatly benefit future EV customers in the geographic region.

Reviewer 2:

The reviewer noted that this effort examines the viability of HD EVs in a cold climate, as well as the use of a battery tied EVSE system to help with grid peak shaving. If successful, the reviewer found that the project could improve local fuel diversity and resiliency through the use of EVs, and other locations with cold-weather operations would benefit from the lessons learned of this project. The reviewer stated that EVs can have significant GHG emissions benefits, but quantity depends on the grid mix serving these vehicles.

Reviewer 3:

The reviewer commented that the project is focused on cold weather operation and deployment of HD EV, which is important to VTO to ensure that EVs are applicable to cold climates.

Reviewer 4:

The reviewer stated that deploying EVs in very challenging duty cycles, with data collection and lessons learned, can help further deployment.

Question 2: Please comment on this project's approach for integrating advanced transportation technologies and practices to solve real-world challenges.

Reviewer 1:

The reviewer observed that all of the components are in place to provide an effective and successful project but expressed concern about the degree of data analysis shown so far. The reviewer expressed the hope that when the EVSE is functioning, data for cost and energy is collected.

Reviewer 2:

The reviewer stated that the project approach to screening vendors that could provide vehicles and equipment suitable for remote locations, cold climates, and the operational needs of the fleet are crucial to the long-term success of the project. The reviewer commented that in the technical notes, the project is demonstrating that the data collection and lessons learned highlight important factors for EVs in snowy/cold climate operations; in addition, they show preliminary information on energy consumption based on local temperatures, showing the impact of cold weather operation. The reviewer observed that monitoring these operational issues through data collection will be a crucial part of the output of this project.

Reviewer 3:

The reviewer commented that the approach seems solid—operate the vehicles, monitor operation, and perform continued maintenance, and the approach also calls for conducting outreach and education to other fleets/locations in the region.

Reviewer 4:

The reviewer found the approach to deploying and testing vehicles to be well-designed, although deployment of heavy refuse vehicles has been delayed.

Question 3: Please comment on the project's progress and significant accomplishments to date.

Reviewer 1:

The reviewer noted good progress, given the situation with equipment reliability and weather challenges, but expressed concern that the amount of DOE funds spent to date does not match what is required for this stage of the project; however, the spending plan was not discussed.

Reviewer 2:

The reviewer observed that the project has had significant delays, and the presenter is the third principal investigator on this project. The reviewer noted that the EVSE and the 220e box truck have been installed and delivered, with some preliminary data being collected; however, this vehicle has had inconsistent usage due to heavy snow events and battery issues causing the vehicle not to be able to charge to 100%. The reviewer added that the stationary battery has yet to be integrated and the two 520 electric garbage trucks have yet to be delivered, with anticipated delivery in fall, due to delays in the supply chain. The reviewer noted that the data from the telematics has been difficult to analyze but stated that the team has worked on improving communications/data sharing between the operator, foreman, and principal investigator, although the system requires that each of the parties manually share data, which could lead to issues with data accuracy. The reviewer highly recommended working on the telematics system to make sure the project is collecting accurate data.

Reviewer 3:

The reviewer commented that one vehicle is up and running and the team is anticipating another two in the fall, and the delays with vehicle delivery are delaying data collection. The reviewer noted that they have initiated the pilot demonstration with the one vehicle received, and that the principal investigator realized that improved communication was required, as were revised data collection procedures, which were both addressed. The reviewer observed that, overall, the project is somewhat behind the planned schedule.

Reviewer 4:

The reviewer commented that good data has been collected from the medium duty box truck deployment, while the deployment of the HD collection vehicles has been delayed.

Question 4: Please comment on the level of collaboration within the project team and the degree to which the project team has identified and leveraged the proper connections to achieve its project goals.

Reviewer 1:

The reviewer stated that it appears the team is functioning well since no concerns were mentioned during the presentation. The reviewer would have liked to have seen more on how the project is being shared and communicated to the public, and to whom, and whether that matches the original plan.

Reviewer 2:

The reviewer commented that the project has faced major delays in obtaining the vehicles and has had issues with the vehicle that has arrived, and it is unclear how well project partners are working together to address the issues delaying the project. The reviewer noted that delivery of vehicles is a tough challenge, but the concern is that the vehicle in hand is not being used as fully as it could due to service issues. The reviewer found it concerning that the project was on its third principal investigator so far and remarked on a lack of leadership to make this effort successful.

Reviewer 3:

The reviewer remarked that it seems like the project had a very committed, though small, team that appears to be working together well, and noted that they were able to pull in Peterbilt to provide additional assistance.

Reviewer 4:

The reviewer noted that team members include other public agencies, an energy authority, and a university, and that the vehicle manufacturer has been involved in various maintenance issues.

Question 5: Please provide comment on the contribution of this project to energy equity and environmental justice by ensuring the project benefits underserved and overburdened communities and does not cause increased burdens to these communities.

Reviewer 1:

The reviewer would have liked to see more of the impacts listed.

Reviewer 2:

The reviewer observed that the project vehicles will operate in an area with very high asthma rates and health insurance stress and that the EVs will provide zero emissions from the vehicle. The reviewer noted that if the project is successful, the use of EVs in rural, cold locations could be increased.

Reviewer 3:

The reviewer indicated that the project included specific elements to address environmentally sensitive areas, though none appear to be focused on DACs.

Reviewer 4:

The reviewer stated that the vehicle is operated in an EJ community.

Presentation Number: TI140
Presentation Title: St. Louis Vehicle Electrification Rides for Seniors (SiLVERS)
Principal Investigator: Connor Herman (Forth Mobility)

Presenter

Connor Herman, Forth Mobility

Reviewer Sample Size

A total of four reviewers evaluated this project.

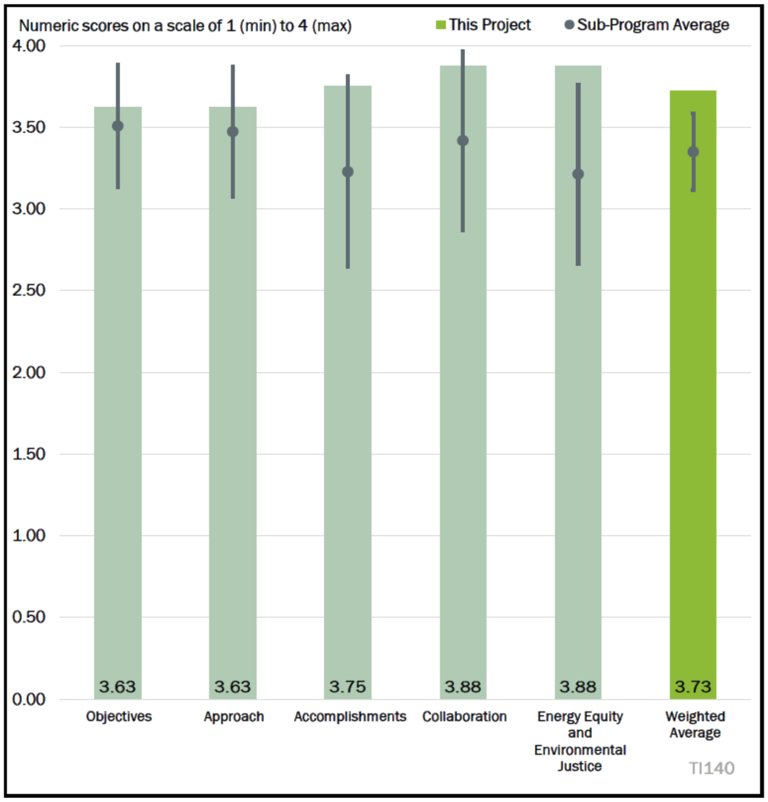

Figure 6-15 - Presentation Number: TI140 Presentation Title: St. Louis Vehicle Electrification Rides for Seniors (SiLVERS) Principal Investigator: Connor Herman (Forth Mobility)

Question 1: Please provide comments on this project's degree of support for the overall Technology Integration (TI) objectives of improving fuel diversity, increasing local resiliency, and reducing greenhouse gas emissions through increasing alternative fuel use and transportation efficiency.

Reviewer 1:

The reviewer observed that the project is a pilot where EVs are used in CBOs, in this case, primarily to provide rides to lower income residents and seniors, and to provide meals delivery. The reviewer found that the project supports all goals above, and its success will likely be replicated throughout the U.S.

Reviewer 2:

The reviewer commented that the project aligns well with the TI goals related to deployment, fuel sources, and resilience.

Reviewer 3:

The reviewer noted that this effort examines the viability of EVs for smaller nonprofits, specifically CBOs that do not have the capacity to analyze the TCO of installing charging and using EVs. The reviewer commented that, if successful, this would provide a model for small fleets that do not have a fleet manager to utilize EVs. The reviewer added that as community-based organizations (CBOs) work with local community members, the successful use of EVs could lead to further EV deployment through word-of-mouth, and in that case, the project could improve local fuel diversity and resiliency, as well as reduce GHG emissions due to the low emission profile of EVs.

Reviewer 4:

The reviewer stated that the project shows a new model for deploying EVs in high impact community services.

Question 2: Please comment on this project's approach for integrating advanced transportation technologies and practices to solve real-world challenges.

Reviewer 1:

The reviewer found that the project approach is solid, with additional steps over and above the "plan, install EVSE, procure, deploy, and report," approach. The reviewer stated that the team had to consider requirements specific to the CBOs with regards to services provided (rides, meal delivery), that staff needed to be trained, CBOs were provided support, and the project included "implementation of public use of chargers." The reviewer indicated that if this model proves financially sustainable after the project ends, social service agencies throughout the U.S., many of which are urban or rural DACs, will adopt this model to provide clean, efficient transportation in areas with air quality issues.

Reviewer 2:

The reviewer indicated that this project utilizes technology and the right partners to impact not only environmental challenges, but social challenges as well.

Reviewer 3:

The reviewer stated that the project consists of three major phases, phase 1 including initiation and launch, phase 2 collecting/analyzing data and refining the project, and phase 3 disseminating lessons learned locally and nationally. The reviewer added that a key part of the project approach was to procure the EVs and install the chargers for the two CBOs participating in the project and then train the staff to use them and noted that the project set aside CBO personnel time for both training and promotion to the community. The reviewer found it to be a good approach to make sure that training for the CBO workers and general technical assistance is a prominent part of the project and added that the project has a detailed plan for disseminating results to several Clean Cities coalitions directly (via hands-on technical assistance), as well as providing presentations of the results at both local and national venues. The reviewer suggested that a case study will be valuable to understand lessons learned.

Reviewer 4:

The reviewer commented that the project successfully demonstrated vehicles and is now sharing lessons learned.

Question 3: Please comment on the project's progress and significant accomplishments to date.

Reviewer 1:

The reviewer found that the accomplishments are impressive: five vehicles deployed at two CBOs focused on seniors; five charging stations installed, over 16,000 meals delivered, and over 1,600 rides given. The reviewer observed that data is being gathered, outreach conducted, a working group developed, and toolkit resources created, and the project team will use the remaining months to refine the model, produce a case study, and share the results.

Reviewer 2:

The reviewer stated that the project has impacts on EV adoption, service to the underserved, and provides a model to follow and complimented the team on its excellent work.

Reviewer 3:

The reviewer commented that the project had tremendous success in procuring the EVs and installing the chargers without significant delays, which was especially impressive due to the pandemic and resulting supply chain issues. The reviewer added that, as that is such a crucial part of the project, it allowed additional project tasks to be completed, and the project has already demonstrated vehicle utilization as well as charging data for more than one year. The reviewer stated that this has put the project on a very good path to being completed and meeting its goals.

Reviewer 4:

The reviewer noted that the vehicles are getting good use and exposing more individuals to EV technology.

Question 4: Please comment on the level of collaboration within the project team and the degree to which the project team has identified and leveraged the proper connections to achieve its project goals.

Reviewer 1:

The reviewer commented that the project team consists of dedicated and enthusiastic community and industry partners and stated that, given the success of this project, it is likely that overall, there was a high level of collaboration. The reviewer observed that Forth Mobility and the team have taken care of the financial burden of insurances, and presumably also maintenance and repairs of EVs and EVSE, cost of electricity to fuel vehicles and any monthly charger network fees. The reviewer suggested that, if not already done, the project team sit down with the agencies using these vehicles and discuss if and how they plan to assume these expenses after the project end date.

Reviewer 2:

The reviewer found the partnership structure to be excellent, including service organizations and a Clean Cities coalition.

Reviewer 3:

The reviewer observed that the project demonstrated significant coordination with project partners in its ability to quickly obtain the EVs, install the chargers, and work with the two CBOs to initiate the project. The reviewer noted that the presentation highlighted the project team is in frequent communication about the status of the project and is trying to engage the team to get feedback on how to improve the project as it proceeds.

Reviewer 4:

The reviewer noted that team members included CBOs, a utility, infrastructure, and vehicle providers, all working together to deliver a successful project.

Question 5: Please provide comment on the contribution of this project to energy equity and environmental justice by ensuring the project benefits underserved and overburdened communities and does not cause increased burdens to these communities.

Reviewer 1:

The reviewer noted that this project's focus is on CBOs, the pilot is operating for the benefit of the population aged 65–74 years old, and the vehicles are serving those in need in an urban community and added that the presenter provided details of demographics in Slide 9.

Reviewer 2:

The reviewer observed that the heart of this project serves an underrepresented group while raising the profile in a metropolitan area that will further benefit underserved populations through the various project benefits.

Reviewer 3:

The reviewer commented that, of the two CBOs participating in the project, one is in a location with a significant percentage of the clientele population being low income and/or a minority, while the other is not in an underserved community, but both are supporting elderly populations. In addition to the direct impact on the communities that the project is involved with, the reviewer stated that the overall lessons learned from the project could lead to other nonprofit groups supporting DACs implementing EVs. The use of EVs offers zero tailpipe emissions in the communities where the vehicles are driven. The reviewer stated that the goal of the project is to demonstrate whether these vehicles are cost-effective and meet the operational requirements of these organizations, and while data was not presented, it was suggested the EVs will have a lower TCO. The reviewer expressed concern that the current upfront costs of EVs will be a challenge for CBOs in the future.

Reviewer 4:

The reviewer noted that the project provides direct services to seniors in need and demonstrated the cleanest transportation technologies in historically DACs.

Presentation Number: TI141
Presentation Title: Integrated Fuel Cell Electric Powertrain Demonstration
Principal Investigator: Patrick Kaufman (Cummins)

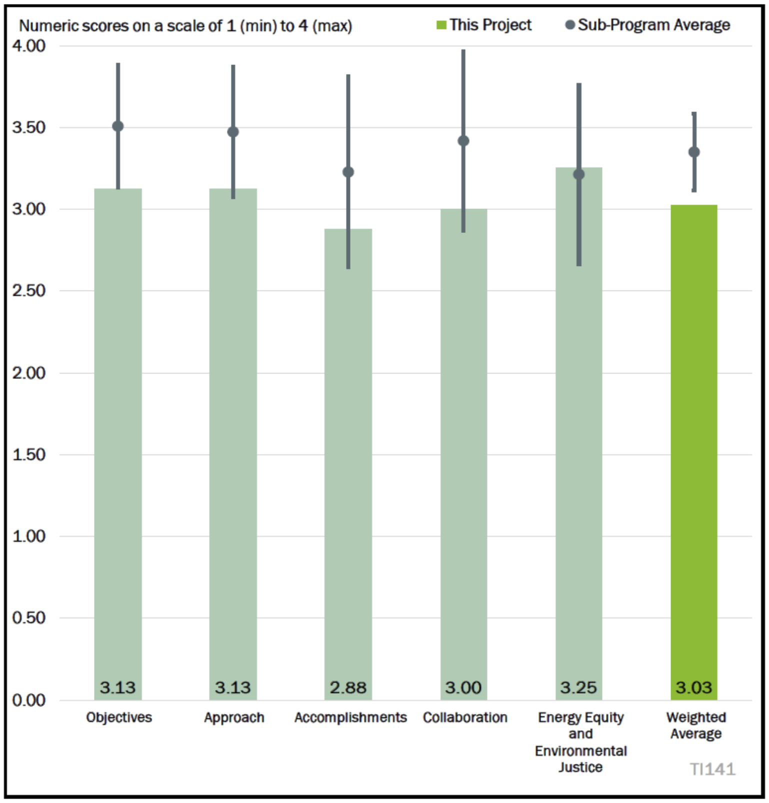

Figure 6-16 - Presentation Number: TI141 Presentation Title: Integrated Fuel Cell Electric Powertrain Demonstration Principal Investigator: Patrick Kaufman (Cummins)

Presenter

Patrick Kaufman, Cummins

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Please provide comments on this project's degree of support for the overall Technology Integration (TI) objectives of improving fuel diversity, increasing local resiliency, and reducing greenhouse gas emissions through increasing alternative fuel use and transportation efficiency.

Reviewer 1:

The reviewer stated that the deployment of hydrogen (H_2) fuel cell trucks and buses is clearly one of the options for reducing GHG in this sector, if the H_2 is renewable, and added that the focus on reducing the TCO of fuel cell powertrains is good. The reviewer commented that the project focus on modular systems to increase component commonality is valid, but is not unique or original, and suggested showing a comparison to other options of net-zero carbon fuel-powertrains.

Reviewer 2:

The reviewer noted that the objective is to develop and demonstrate a modular and scalable integrated fuel cell electric powertrain for use in HD trucks and buses. The reviewer added that the expected outcome of the project is a market-ready fuel cell electric powertrain whose operational performance and TCO will support near-term, rapid, and substantial penetration of the truck and bus markets. The reviewer stated that if the project is successful, it will help reduce costs of hydrogen fuel cell commercial vehicles. The reviewer added that DOE funding will bring to market a unique and cost-competitive zero-emission powertrain solution that can be scaled to other HD vehicle markets like marine and industrial applications; these are sound obtainable objectives.

Reviewer 3:

The reviewer observed that the project is focused on developing a modular, market ready H_2 fuel cell drive train for use in HD vehicles (trucks and buses). The reviewer commented that this is the key market sector for fuel cells for transportation to add another zero-emission option, the expectation being that the drivetrain can also be scaled to other applications (marine, industrial, etc.). The reviewer noted that, with the bus OEM pulling out, it has reduced the scope of the project, but the project will still be important for the truck market.

Reviewer 4:

The reviewer expressed the view that this is exactly the type of project DOE should be funding to help accelerate the development and deployment of new technologies that involve significant risk but provide large benefits if successful. The reviewer added that the project satisfies all the above criteria related to fuel diversity, etc.

Question 2: Please comment on this project's approach for integrating advanced transportation technologies and practices to solve real-world challenges.

Reviewer 1:

The reviewer commented that, in general, it is not shown that this project will greatly improve the market viability of fuel cell trucks and buses beyond what has been learned in many previous similar demonstrations and incentivized applications. The reviewer added that the project is in early phases and may have more information in the future, but the bus partner dropping out is a negative and the quantitative TCO analysis was not shown. The reviewer stated that the project needs comparison to a baseline and prior work to show how this project will "move the needle." The reviewer added that there is not much/any attention to the H_2 fuel supply and questioned whether the H_2 infrastructure in the area has already been built and whether green H_2 is being used.

Reviewer 2:

The reviewer summarized that the approach is sound and has three phases for integrated fuel cell powertrain design/assembly, vehicle testing and technology commercialization. Phase 1, design of a modular and scalable integrated fuel cell electric powertrain by leveraging existing fuel cell powertrains. Phase 2, vehicle testing, demonstration and evaluation of the prototype vehicles will be tested for performance, safety, durability, and reliability in operation closely simulating the drive cycles typically taken by the end-user fleets, delivered to the end-user fleets, and operated in real-world conditions covering both hot and cold climate. Phase 3, technology commercialization public outreach activities will help establish strong relationships throughout the hydrogen ecosystem to support future commercialization efforts. The reviewer noted that an actionable technology deployment plan will be laid out to complete the introduction to market of the integrated fuel cell electric powertrain, achieve high production volumes at reduced costs, and identify a viable pathway for commercialization to achieve near term, rapid, and substantial penetration of the truck and bus market.

Reviewer 3:

The reviewer stated that the project approach is well-designed to achieve the overall goals of the project and includes specific performance metrics. The reviewer noted that the original approach focused on design, testing, and then commercialization (outreach/deployment/work with OEMs), but the team is proposing to move up commercialization from phase 3 to phases 1 and 2.

Reviewer 4:

The reviewer commented on the sound project approach with well thought out plan.

Question 3: Please comment on the project's progress and significant accomplishments to date.

Reviewer 1:

The reviewer noted that the project appears to still be in early phases; definition of architecture is shown, but quantitative analysis results are lacking. The reviewer commented that an unfortunate situation exists with the bus partner.

Reviewer 2:

The reviewer observed that project accomplishments and progress include applied technology improvements with sub-systems/modules wherein improvements are being realized are as follows: next-generation higher power fuel cell engine, new high-power battery packs better suited to fuel-cell applications, eAxle traction system for Class 8 application and direct drive traction improvement for transit bus application, and a 700bar H_2 storage system with more H_2 capacity for Class 8 applications. The reviewer noted that on the fuel cell truck the team worked with Navistar on an amendment to the Navistar agreement to clarify roles and responsibilities, partially based on the improvements listed above. On the fuel cell bus, the OEM has agreed in principle to partner with Cummins on this project. Both a memorandum of understanding and contract are in continued negotiations. The reviewer stated that OEM and fleet requirements were reviewed and finalized; they received 60% of vehicle information, including computer aided design models of stock bus; detailed architecture is frozen; major components were confirmed based on the simulation results to meet OEM preferred duty cycle (fleet requirements); 10% of component layout work is completed; and concept bill of materials defined. The reviewer noted that the project team engaged fleet partners to gather the voice of customers and better understand their requirements.

Reviewer 3:

The reviewer stated that the team seems to be completing most of its milestones as planned, though some have moved out in time, balanced against commercialization elements that have been moved up to earlier in the timeline. The reviewer added that the project team has also decided to adopt some newer technologies (next-gen fuel cell and e-axle) than originally planned, though this has called for some delay in specific design and testing deadlines; this was done to make sure that the latest and best technologies are incorporated. The reviewer commented that Cummins has looked carefully at the cost impacts of the newer technologies and does not expect any significant overall changes, with improved performance. Further, the fuel cell bus OEM dropped out in December 2022 so Cummins has asked to cut the bus portion of the project due to difficulties in finding a replacement OEM; this would cut the project in half. The reviewer noted that Cummins expects that the technology developed will be adoptable for buses.

Reviewer 4:

The reviewer commented that the truck project is on track and appears to be going well, but the bus project has been cancelled, resulting in a somewhat lower ranking here.

Question 4: Please comment on the level of collaboration within the project team and the degree to which the project team has identified and leveraged the proper connections to achieve its project goals.

Reviewer 1:

The reviewer stated that the overall team looks solid and comprehensive, and the expectation is that Cummins will lead the effort to good results. The reviewer noted that the fuel supplier does not seem to be identified.

Reviewer 2:

The reviewer commented that a very strong team is assembled, and coordination is very good. The reviewer further summarized the project collaboration: Cummins Electrified Power NA Inc. (Cummins) is the recipient and will provide overall project management, task coordination, and administrative functions for the project. Cummins will also manage all the technical tasks, working with Navistar to design the integrated fuel cell electric powertrain. Cummins will build, commission, and test the prototype fuel cell vehicle, providing service and support during the field demonstration Werner Enterprises. CALSTART, with Cummins' guidance, will manage data collection and analysis, develop the product development and manufacturing plan, and the technology commercialization pathway. Long Beach Clean Cities will hold community outreach events. SoCalGas will provide additional funding to the project, and additional funding partners are being sought. Each of the partners listed will participate in regular project meetings and reviews and provide feedback to the Project Team on policies and legislation driving the hydrogen economy and the commercialization of fuel cell and hydrogen technologies.

Reviewer 3:

The reviewer stated that the project has an impressive team put together with representatives from key sectors and noted that the principal investigator has been working closely with the truck manufacturer to find out more about its specific technical needs. The bus manufacturer pulled out completely, resulting in a request to cut the bus portion of the project. The reviewer noted that, given the bus manufacturer pulling out, the regional bus operator and Clean Fuels Ohio will no longer be on the team and summarized by stating that the team has collaborated well on the truck side, but the bus side of the project did not go well.

Reviewer 4:

The reviewer noted that collaboration between Cummins and Navistar appears to have resulted in improvements and positive changes to development of the fuel cell system. The reviewer added that the project rating would have been higher if the bus project were still on track.

Question 5: Please provide comment on the contribution of this project to energy equity and environmental justice by ensuring the project benefits underserved and overburdened communities and does not cause increased burdens to these communities.

Reviewer 1:

The reviewer stated that, if successful, the improved viability of this zero-tailpipe-emission system will benefit everyone and noted that the restoration of a bus OEM and success in the bus transit area may have higher value to low-income communities.

Reviewer 2:

The reviewer observed that contributions to EEEJ include an estimated 38,900 gallons of diesel fuel that will be displaced annually. Each fuel cell transit bus will reduce 13,900 gallons, and each Class 8 truck will reduce 25,000 gallons. The reviewer stated that the vehicles will be operating in disadvantaged areas.

Reviewer 3:

The reviewer commented that the technology would result in significant fossil fuel and emission reductions; however, no specific mention was made on benefits to DACs.

Reviewer 4:

The reviewer stated that the benefits of projects like this will be realized at a later time when the vehicles and systems are deployed, so “Good” is probably the best rating the project could achieve now.

Presentation Number: TI142
Presentation Title: Field Demonstration of a Near-Zero, Tier 5 Compliant, Natural Gas Hybrid Line-Haul Locomotive
Principal Investigator: Ted Barnes and Bart Sowa (Gas Technology Institute)

Presenter

Ted Barnes, Gas Technology Institute

Reviewer Sample Size

A total of four reviewers evaluated this project.

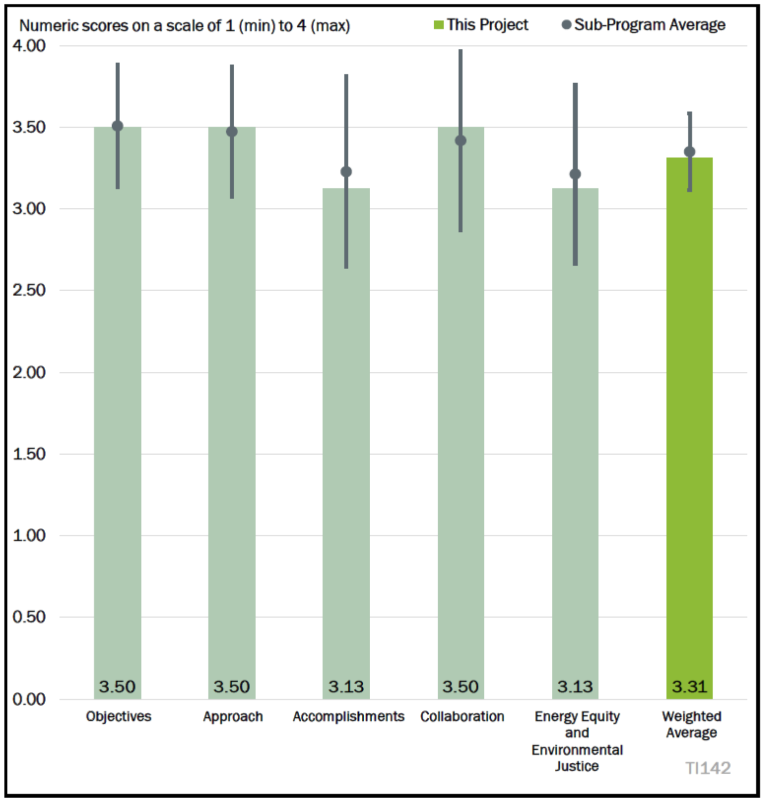

Figure 6-17 - Presentation Number: TI142 Presentation Title: Field Demonstration of a Near-Zero, Tier 5 Compliant, Natural Gas Hybrid Line-Haul Locomotive Principal Investigator: Ted Barnes and Bart Sowa (Gas Technology Institute)

Question 1: Please provide comments on this project's degree of support for the overall Technology Integration (TI) objectives of improving fuel diversity, increasing local resiliency, and reducing greenhouse gas emissions through increasing alternative fuel use and transportation efficiency.

Reviewer 1:

The reviewer commented that the project can make a strong contribution to decarbonizing rail through deployment of renewable natural gas (RNG), augmented by a hybrid system to improve efficiency and extend the supply of renewable fuel. The reviewer observed that it appears to require no major infrastructure change and stated that the determination of hybrid benefits will be an excellent technical contribution.

Reviewer 2:

The reviewer stated that this project supports the TI objectives. The reviewer also stated that, if the final efficiency were only 20%, a reduced rating would be warranted, but a 40% efficiency gain is a substantial improvement.

Reviewer 3:

The reviewer noted that the project is aimed at reducing emissions and improving fuel diversity for a sector characterized by high emissions (GHGs and criteria pollutants) and conventional fuel use, and thus, this ties very well to VTO objectives.

Reviewer 4:

The reviewer stated that locomotives, while an efficient means of moving goods, produce large emissions and consume a significant amount of fuel, and demonstrating the ability to deploy a more efficient system powered by alternative fuel supports TI's overall objectives identified above.

Question 2: Please comment on this project's approach for integrating advanced transportation technologies and practices to solve real-world challenges.

Reviewer 1:

The reviewer commented that an excellent team has been assembled and the approach of retrofitting an existing locomotive is constructive for GHG reduction and cost effectiveness. The reviewer requested information on restrictions on moving compressed gases and Li-ion batteries through railroad tunnels.

Reviewer 2:

The reviewer indicated that the technologies chosen appear to be well suited to the task, but suggested that some up-front analysis could have been done to understand a baseline duty cycle and performance so that the hybrid system could be engineered in a smarter way, rather than waiting solely on final test result.

Reviewer 3:

The reviewer stated that the approach has been laid out in a logical manner, with clear elements for each BP and found it particularly beneficial that the team is looking at the potential for retrofitting existing locomotives, which stay in operation for a very long time. The reviewer added that the re-power market is large, with over 5000 of the models of locomotive being used in operation. The reviewer noted that safety reviews are also built into the approach.

Reviewer 4:

The reviewer commented that using existing systems and a module approach is outstanding because others could easily implement this concept.

Question 3: Please comment on the project's progress and significant accomplishments to date.

Reviewer 1:

The reviewer noted that the team acknowledged some COVID delays but has made good progress on overall design and sourcing of key components.

Reviewer 2:

The reviewer stated that, even though the project endured delays due to COVID, it appears they are making up ground and may finish close to the original plan.

Reviewer 3:

The reviewer commented that all BP 1 milestones were completed, though there were some schedule impacts due to COVID, and the team received a no-cost extension for BP 1. The reviewer noted that, for BP 2, they have started all activities and believe they are on schedule to build by the end of the year so testing can be done in 2024.

Reviewer 4:

The reviewer observed that the project has been delayed due to COVID related issues and this has impacted accomplishments to date.

Question 4: Please comment on the level of collaboration within the project team and the degree to which the project team has identified and leveraged the proper connections to achieve its project goals.

Reviewer 1:

The reviewer commented that team roles are complementary and on path.

Reviewer 2:

The reviewer noted that collaboration and coordination appear successful due to the current status of the project.

Reviewer 3:

The reviewer observed that the project team includes participants from several of the key sectors to achieve project goals; in particular, testing will be conducted at the Federal Railroad Administration's test facility, and the team is in conversation with rail operators to put the locomotive into operation. The reviewer noted that the team is working with gas utilities, including a collaborative of 20 gas utilities, that are cost-sharing some of the activities. The reviewer added that the team has been actively working with its industry members and participating with rail industry events and has plans to do more in the future, and they have also been interacting with regulatory agencies.

Reviewer 4:

The reviewer stated that most of the collaboration so far has been on the engineering side, and no problems have been indicated, and added that it will be important to see the degree of collaboration and coordination when production starts.

Question 5: Please provide comment on the contribution of this project to energy equity and environmental justice by ensuring the project benefits underserved and overburdened communities and does not cause increased burdens to these communities.

Reviewer 1:

The reviewer stated that the project is on path to benefit everyone; a good point is made that low-income communities are sometimes near rail yards that will get emission reduction with this technology, although rail traffic travels through almost all categories/demographic areas.

Reviewer 2:

The reviewer noted that air quality improvements with this technology are obvious, but suggested adding partners that would help monitor and judge the effort to ensure the technology is offered to railyards, so that it can positively impact the health of the surrounding population.

Reviewer 3:

The reviewer stated that the expectation by the project team is that the technology under development will ultimately provide significant energy and environmental benefits in overburdened communities, as rail operations tend to be centered in these communities and noted that the near-term impacts may be small from a single locomotive, but the ultimate impacts could be large.

Reviewer 4:

The reviewer commented that the benefits will come later, and if this project is successful, it could have a major very positive impact on affected communities in urban areas due to the high emissions trains operating in those areas normally produce, which add to the already high industrial emissions often found in urban areas.

Presentation Number: TI143
Presentation Title: Medium-Duty Electric Truck (Etruck): Pilot Electrified Fleets in Urban and Regional Applications
Principal Investigator: Junmin Wang (University of Texas-Austin)

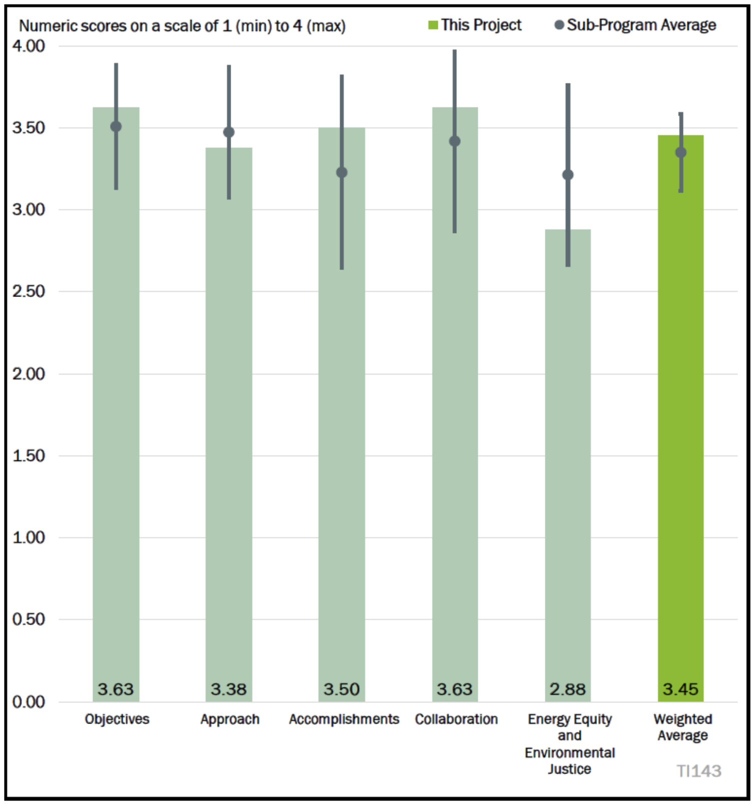

Figure 6-18 - Presentation Number: TI143 Presentation Title: Medium-Duty Electric Truck (Etruck): Pilot Electrified Fleets in Urban and Regional Applications Principal Investigator: Junmin Wang (University of Texas-Austin)

Presenter

Junmin Wang, University of Texas-Austin

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Please provide comments on this project's degree of support for the overall Technology Integration (TI) objectives of improving fuel diversity, increasing local resiliency, and reducing greenhouse gas emissions through increasing alternative fuel use and transportation efficiency.

Reviewer 1:

The reviewer found the project plan and purpose to be well suited to the TI goals but questioned the rationale for choosing two geographic locations instead of one, which might have made the project more efficient in spending and activity.

Reviewer 2:

The reviewer stated that the objective of this project is to provide fleets in Texas and Tennessee with the opportunity to demonstrate medium duty electric trucks in urban and regional delivery applications and noted that by providing a significant number of fleets the opportunity to demonstrate these vehicles, they are increasing the likelihood that these fleets will purchase EVs in the future. The reviewer commented that, if successful, this could improve local fuel diversity and resiliency through the use of EVs. The reviewer added that EVs can have significant GHG emissions benefits, but the quantity of those benefits depends on the grid mix serving these vehicles.

Reviewer 3:

The reviewer noted that the project is focused on MD EV trucks, an area with relatively little data to date, and the project team will be deploying them in urban and regional fleet applications and collecting data. The reviewer observed that the vehicles targeted for replacement often operate in high emission areas and have duty cycles that can match well with EV truck capabilities.

Reviewer 4:

The reviewer found the project had solid objectives to deploy and demonstrate multiple vehicles and share lessons learned.

Question 2: Please comment on this project's approach for integrating advanced transportation technologies and practices to solve real-world challenges.

Reviewer 1:

The reviewer stated that the approach described should lead to success but suggested that an understanding and discussion of exactly what data analysis reports are expected would be beneficial.

Reviewer 2:

The reviewer commented that the project has the goal of providing electric trucks to 40 fleets to demonstrate and found that the project has a robust data collection plan to analyze the usage of the vehicles in the various fleet duty cycles. The project will utilize this data to help develop simulation models for electric truck usage. The reviewer noted that each fleet in the project will be given a pre- and post-study survey, with versions for both the driver and fleet manager, and the survey will help understand the positives and negatives for both operation and management of these vehicles. In addition, the project will collect data to support which duty cycles work well with these vehicle types. The reviewer observed that the project has a number of outreach and education events to discuss the project; however, it is unclear what the final output of the study will be. The reviewer noted that the presenter mentioned information exchange and outreach activities, but strongly recommended the project team look to develop a final summary report and presentation that details all the information from the study. The reviewer added that case studies from fleets where things did not work and did work would be valuable to demonstrate the lessons learned from this project.

Reviewer 3:

The reviewer found that the project has a clear approach, with three trucks spread over two sites for demonstration; overall, the project team is looking at demonstrating the vehicles in 40 fleets. The reviewer noted that all BPs include specific elements focused on information exchange, outreach, and education, and the project includes post-use surveys. The reviewer commented that there are no plans to collect data on the baseline diesel vehicles but suggested that might be a useful addition at some point, if possible, under the budget and if fleets agree.

Reviewer 4:

The reviewer commented that the use of a driver survey and interviews in addition to telematics data collection will lead to a rich dataset.

Question 3: Please comment on the project's progress and significant accomplishments to date.

Reviewer 1:

The reviewer stated that the project appears to have been successful to date but did not recall hearing about the progress of charging station installations.

Reviewer 2:

The reviewer observed that the project was able to get the first two trucks in operation in 2020 and 2021 and found that to be very commendable considering the supply chain issues for EVs; in addition, the project was able to obtain the third truck in 2023. The reviewer noted that the project has already had six fleets demonstrate the vehicles, with a goal of a total of 40 demonstrations by the end of the project, each of the fleets had a Level 2 charger installed, and the project made a major effort to set up its telematics/data logger systems to be able to collect very detailed data from each vehicle in real time. The reviewer noted that the project has already used that data to develop a simulation-based vehicle model for these medium duty electric trucks and the project has developed a pre- and post-study survey to evaluate each fleet's awareness/acceptance of electric trucks. The reviewer added that the project has already participated in several outreach and education events in both Tennessee and Texas.

Reviewer 3:

The reviewer noted that the team received its trucks in BP 1, calling that a major accomplishment, and the trucks are up and running and have been moving through the demonstration fleets. The reviewer commented that they appear to have started all their BP 2 milestones. The reviewer observed that they did have to change the manufacturer for one of the trucks—the one for Tennessee, but all data acquisition systems have been set up, fleet recruitment is on-going, and the team has established a specific process for agreements with the fleets. The reviewer commended the team on having done an impressive amount of education and outreach, as well.

Reviewer 4:

The reviewer observed that, despite supply chain delays, the team has put vehicles from multiple manufacturers in service, initiated data collection, and made multiple presentations and publications.

Question 4: Please comment on the level of collaboration within the project team and the degree to which the project team has identified and leveraged the proper connections to achieve its project goals.

Reviewer 1:

The reviewer stated that collaboration and communication to participants and external stakeholders about the project seems to be well planned. The reviewer was unsure of the extent of collaboration for the chargers, as very little was discussed on this topic.

Reviewer 2:

The reviewer noted that the project has managed to recruit a significant number of fleets to participate in both Texas and Tennessee, the team was able to obtain EVs at a time where their supply was very limited, and they have worked on a data collection plan to outfit these vehicles with data loggers and wirelessly collect the information. The reviewer commented that there were not a lot of additional details in the presentation on how the project team collaborates and coordinates, so it is difficult to rate the project on this question, but added that, with the significant accomplishments the project has shown already, it seems the project team is doing a good job.

Reviewer 3:

The reviewer commented that the project has an impressive roster of partners, including state, regional, and national organizations, and Texas and Tennessee trucking associations, to get the word out on the project’s results. The reviewer stated that the project team appears to have been working together closely to ensure achievement of project goals and maximum impact through fleet involvement and outreach.

Reviewer 4:

The reviewer observed that multiple partners across Texas and Tennessee include universities, national laboratories, Clean Cities coalitions, vehicle providers, and fleets, and commended the team on strong outreach and engagement at regional events.

Question 5: Please provide comment on the contribution of this project to energy equity and environmental justice by ensuring the project benefits underserved and overburdened communities and does not cause increased burdens to these communities.

Reviewer 1:

The reviewer stated that there was some discussion about the impacts, but no actual plans or partners appear scheduled.

Reviewer 2:

The reviewer noted that the project goal is to provide a wide range of fleets, many financially constrained or relatively small, with the ability to demonstrate EVs and, while not directly relating to EEEJ, if the project is successful in increasing the deployment of MD EVs, there would be beneficial impacts to the communities in which they operate. The reviewer commented that, from the presentation, it was not clear how many of the fleets were operating in DACs.

Reviewer 3:

The reviewer found that the project team has specifically considered the benefits for DACs as well as how to minimize the impact on sensitive areas/neighborhoods, and they have focused much of their outreach on both small business fleets and government decision-makers.

Reviewer 4:

The reviewer stated that providing electric truck opportunities to small or financially constrained trucking fleets will help amplify the general benefits that EVs bring to pollution burdened communities.

Presentation Number: TI144
Presentation Title: Creating the NFPA Distributed Energy Resources Safety Training (DERST) Program
Principal Investigator: Andrew Klock (National Fire Protection Association)

Presenter

Andrew Klock, National Fire Protection Association

Reviewer Sample Size

A total of three reviewers evaluated this project.

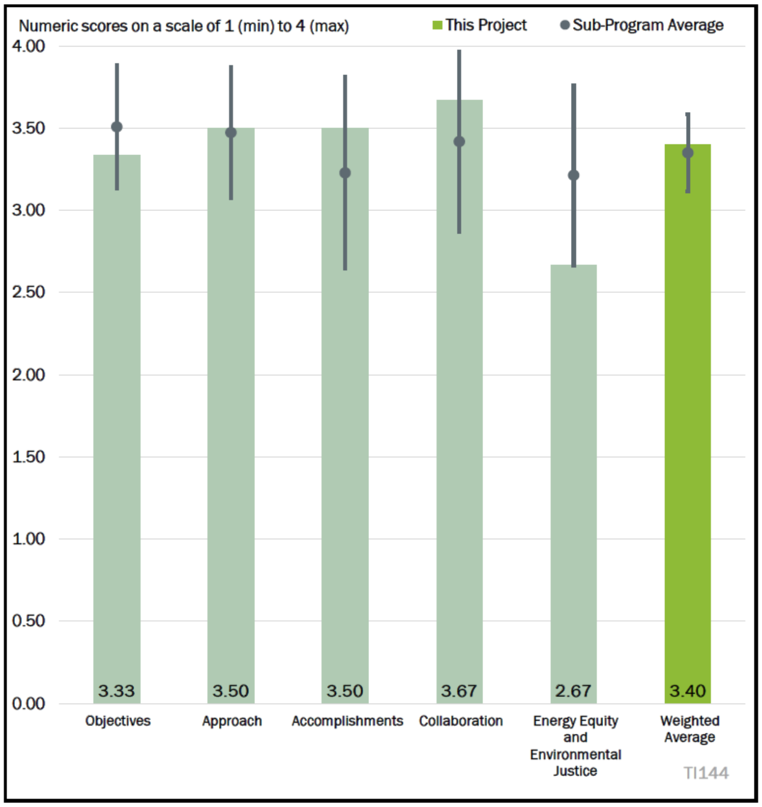

Figure 6-19 - Presentation Number: TI144 Presentation Title: Creating the NFPA Distributed Energy Resources Safety Training (DERST) Program Principal Investigator: Andrew Klock (National Fire Protection Association)

Question 1: Please provide comments on this project's degree of support for the overall Technology Integration (TI) objectives of improving fuel diversity, increasing local resiliency, and reducing greenhouse gas emissions through increasing alternative fuel use and transportation efficiency.

Reviewer 1:

The reviewer commented on the unique focus to improve training practices for first responders and increase the reach of trainings.

Reviewer 2:

The reviewer stated that this project is important and should be required to be provided to communities when any type of distributed energy resources (DER) project gets built. The reviewer found that it definitely increases local resiliency but does not achieve the other objectives.

Question 2: Please comment on this project's approach for integrating advanced transportation technologies and practices to solve real-world challenges.

Reviewer 1:

The reviewer found that the approach proceeds logically, starting with collection and testing data, analyzing findings, and then updating trainings based on these findings. The reviewer stated that this approach also combines trainings on different distributed energy resources (DER) technologies that were treated separately.

Reviewer 2:

The reviewer commented that vehicle to grid (V2G) technology is growing quickly, and it is important that emergency responders know what they are looking at when they see a vehicle battery being used as a grid asset. The reviewer added that in-person demonstrations are so important, too.

Question 3: Please comment on the project's progress and significant accomplishments to date.

Reviewer 1:

The reviewer really appreciated the gamification approach.

Reviewer 2:

The reviewer found that the project has achieved its early objectives, and contractors appear capable of building the simulation that is a key deliverable for later BPs.

Reviewer 3:

The reviewer stated that this project has achieved all of its goals to date.

Question 4: Please comment on the level of collaboration within the project team and the degree to which the project team has identified and leveraged the proper connections to achieve its project goals.

Reviewer 1:

The reviewer found the biweekly meetings between project team partners to be effective, and noted good collaboration between NFPA, the university and the national laboratories.

Reviewer 2:

The reviewer observed that this project brought together many different project partners that had to work together to make it successful.

Question 5: Please provide comment on the contribution of this project to energy equity and environmental justice by ensuring the project benefits underserved and overburdened communities and does not cause increased burdens to these communities.

Reviewer 1:

The reviewer noted the training design to minimize barriers to access but suggested that the project do more to focus on the specific needs of historically underserved communities and fire departments in both content and marketing.

Reviewer 2:

The reviewer commented that training is needed in all communities, although DERs tend to be deployed more in wealthier communities. The reviewer stated that NFPA has a strategy to make sure materials are available across communities.

Reviewer 3:

The reviewer stated that targeted outreach to overburdened communities is something to consider moving forward.

Presentation Number: TI145
Presentation Title: Electric Vehicle Market Stimulation in Divested Economies
Principal Investigator: Miriam Bouallegue (Metropolitan Energy Center)

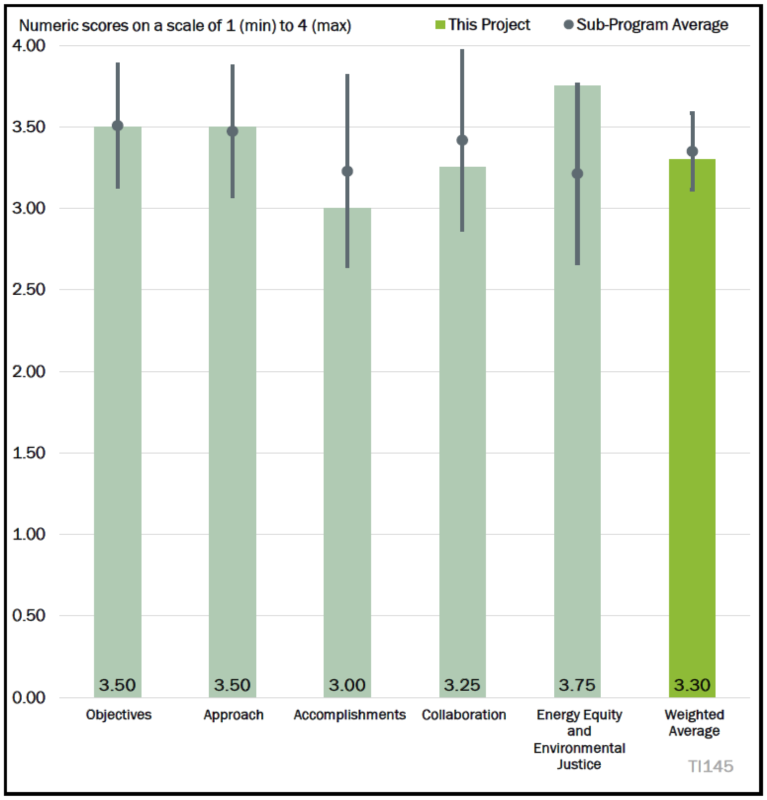

Figure 6-20 - Presentation Number: TI145 Presentation Title: Electric Vehicle Market Stimulation in Divested Economies Principal Investigator: Miriam Bouallegue (Metropolitan Energy Center)

Presenter

Miriam Bouallegue, Metropolitan Energy Center

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Please provide comments on this project's degree of support for the overall Technology Integration (TI) objectives of improving fuel diversity, increasing local resiliency, and reducing greenhouse gas emissions through increasing alternative fuel use and transportation efficiency.

Reviewer 1:

The reviewer found that the project clearly achieves TI goals by increasing local fuel diversification and increasing affordability for consumers.

Reviewer 2:

The reviewer noted that the project team very clearly stated their relevance to the TI programmatic objectives, but they provided the project objectives at a higher level.

Reviewer 3:

The reviewer commented that this project is a "leading by example" project by employing EVs and EVSE in municipal settings.

Reviewer 4:

The reviewer stated that this is an ambitious opportunity to engage the community and provide exposure to EVs and commercial EVSE infrastructure, and, if successful, it will deploy HD EVs and charging infrastructure in DACs improving fuel diversity, increasing resiliency, and reducing GHGs. The reviewer questioned whether the project goals are attainable and how the team plans to find commercial entities that can meet cost-match requirements. The reviewer further questioned how the project will meet the objective of paying special attention to multifamily residents.

Question 2: Please comment on this project's approach for integrating advanced transportation technologies and practices to solve real-world challenges.

Reviewer 1:

The reviewer commended the project's focus on community engagement to ensure that this technology is implemented in a way that is responsive to the input of DACs.

Reviewer 2:

The reviewer stated that the project approach was described and includes a number of logical steps for each BP, but suggested the project team may need to consider how they would pivot their approach if supply chain issues persist and technology availability is limited. The reviewer added that the project team may also want to consider how to more specifically explore adjacent economic development opportunities and business models that might work in rural settings.

Reviewer 3:

The reviewer commented that getting EV terminal tractors in use is impressive.

Reviewer 4:

The reviewer observed that this project uses a two-pronged approach to meet the objectives that will involve dedicated project management and coordination. The reviewer commended the team on the dedicated community engagement plan early in the process to ensure EV charging stations are placed in the right locations for DACs and noted that a strategic plan for other cities will also expand the impact of this project. The reviewer stressed the importance of a cost share that will be feasible for local entities.

Question 3: Please comment on the project's progress and significant accomplishments to date.

Reviewer 1:

The reviewer found the amount of project funds spent thus far to be somewhat concerning, along with very few milestones achieved at this point but added that community engagement is rightfully a slow process and that can be a contributor to the limited progress so far.

Reviewer 2:

The reviewer stated that the project, like many projects, is experiencing supply chain delays and constraints in market availability of EVs and EVSE infrastructure. The reviewer noted that one of the CBOs has been identified and the other one is still in progress, and the EVSE contractors have been selected for more than a quarter of the planned sub recipient projects. The reviewer found that the project team provided some context and background on the progress of the milestones, describing the community engagement and outreach methods and events. The project team has held six events so far. The reviewer noted that they have been trying to deploy HD vehicles from manufacturers that have not had supply chain issues, including deployment of three EV terminal tractors.

Reviewer 3:

The reviewer noted that they have identified EJ communities that need a reduction of emissions and found this to be a positive step.

Reviewer 4:

The reviewer observed that only 2% of the budget has been spent so far. The reviewer appreciated that the community engagement process has been a priority, as it is important to include this in the early planning stages but noted that three vehicles have been purchased so far, and site selection for EVSE infrastructure has just begun. The reviewer questioned the feasibility of completing the project by the May 31, 2025, deadline.

Question 4: Please comment on the level of collaboration within the project team and the degree to which the project team has identified and leveraged the proper connections to achieve its project goals.

Reviewer 1:

The reviewer stated that the team has been successful with the standard players including municipalities, nonprofits, colleges, and industry but noted that a key missing group is local advocacy organizations and those representing DACs, and they should be part of the stakeholder set.

Reviewer 2:

The reviewer noted that the project team anticipates that the partner list will grow, and private sector organizations will provide cost share overmatch, and suggested that they consider engaging with local financial and economic development entities to determine how project efforts might also explore the connection with local wealth building from various aspects of the project.

Reviewer 3:

The reviewer commented that it looks like the team is getting things done.

Reviewer 4:

The reviewer noted that the project provided a list of partners and collaborations but suggested that more detail regarding their specific roles in the project would be helpful. The reviewer appreciated the inclusion of cities and underserved CBOs in the process.

Question 5: Please provide comment on the contribution of this project to energy equity and environmental justice by ensuring the project benefits underserved and overburdened communities and does not cause increased burdens to these communities.

Reviewer 1:

The reviewer noted that community engagement is a challenging but essential component for technology implementation and that this project relies heavily upon it. The reviewer found that there are clear air quality and EEEJ benefits of the project, though more limited direct benefits beyond that for DACs. The reviewer added that engagement ensures that the desires of DACs will be heard regarding potential benefits and avoidance of burdens from the project.

Reviewer 2:

The reviewer stated that the project team did outline a few energy and environmental justice benefit areas and there was some discussion of how they would track those benefits. The reviewer suggested that the project team consider how to more clearly track or explore how the project or similar efforts can build wealth in the communities where they are deployed.

Reviewer 3:

The reviewer commented that the involvement of the cities goes a long way to getting things moving in EJ communities.

Reviewer 4:

The reviewer appreciated the identification of underserved communities and engaging them in the process of deploying HD electric fleet vehicles and added that community collaboration in placing charging stations should contribute to EEEJ benefits. The reviewer found no estimate of the tangible impact, such as projected GHG and air pollutant reduction of these efforts, however, and suggested that quantifying these impacts will make the benefits clearer to reviewers as well as to the communities themselves.

Presentation Number: TI146
Presentation Title: Rural Reimagined: Building an EV Ecosystem and Green Economy for Transforming Lives in Economically Distressed Appalachia
Principal Investigator: Pingen Chen (Tennessee Tech)

Presenter

Pingen Chen, Tennessee Tech

Reviewer Sample Size

A total of four reviewers evaluated this project.

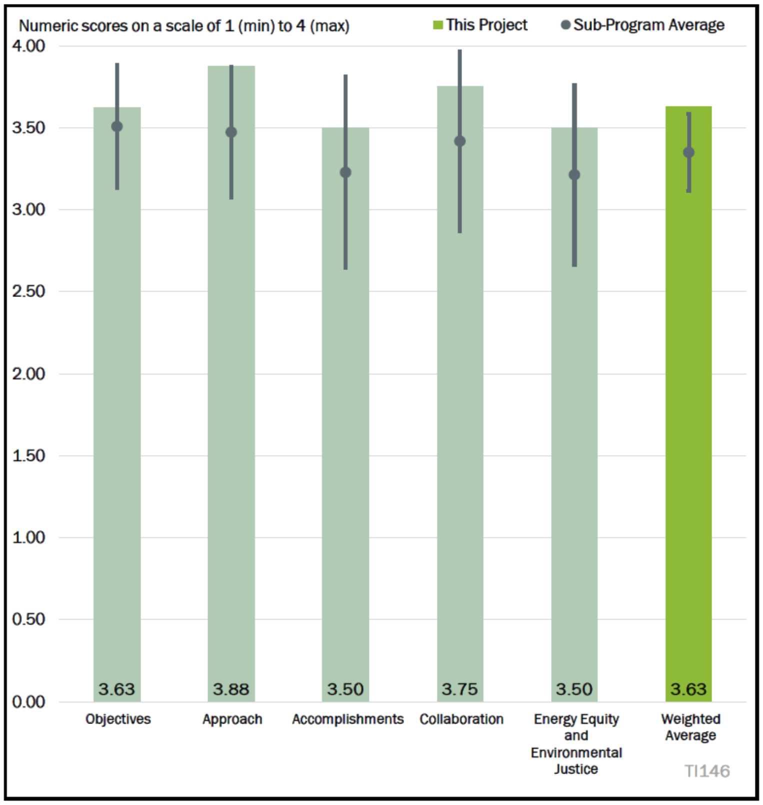

Figure 6-21 - Presentation Number: TI146 Presentation Title: Rural Reimagined: Building an EV Ecosystem and Green Economy for Transforming Lives in Economically Distressed Appalachia Principal Investigator: Pingen Chen (Tennessee Tech)

Question 1: Please provide comments on this project's degree of support for the overall Technology Integration (TI) objectives of improving fuel diversity, increasing local resiliency, and reducing greenhouse gas emissions through increasing alternative fuel use and transportation efficiency.

Reviewer 1:

The reviewer stated that the objectives are clear and well-aligned with TI goals, particularly fuel diversity, economic growth, affordability, and resilience.

Reviewer 2:

The reviewer commented that this project can be a very positive example of how to deal with Rural America and EVs and found the hands-on approach to be a great idea and a way to help people understand what driving an EV is all about.

Reviewer 3:

The reviewer found that this project is doing an excellent job of meeting several TI objectives. It supports the objective of national security by increasing the diversity of transportation fuels available; the objective of economic growth by providing business opportunities and workforce training; and the objective of increasing affordability via the cost-savings associated with EV adoption.

Reviewer 4:

The reviewer stated that this project offers opportunities to address systemic issues related to EVs in Appalachia such as inequity, economic opportunity, and public perception. The reviewer added that it appears to provide EV operation and use data specific to rural communities that could be useful in similar applications across the country.

Question 2: Please comment on this project's approach for integrating advanced transportation technologies and practices to solve real-world challenges.

Reviewer 1:

The reviewer found the project approach to be wide-ranging and comprehensive, and if achieved, it would be an incredible undertaking. The reviewer's only concern was that the scope is immense and accomplishing it with the given budget will be quite ambitious.

Reviewer 2:

The reviewer stated that organizing BEV events in the region was a great idea because Rural America sometimes does not have the capacity to get the public involved.

Reviewer 3:

The reviewer commented that the approach touches many elements of EV adoption for both individual consumers and businesses and attempts to address many of the barriers that those groups encounter, including access to EV charging and awareness and exposure to EVs. The reviewer noted that the project endeavors to implement strategies to help rural communities lower the burden of EVSE investment by paying a portion of the installation costs. In addition, the project has established an EV infrastructure working group made up of a diverse group of partners.

Reviewer 4:

The reviewer stated that the approach of this project appears to be very broad and considers many of the possible concerns and expressed appreciation for the idea of a "comprehensive EV ecosystem and green economy" in an area that without this project would likely fall behind others in EV education and adoption. The reviewer commented that the focus on regional workforce development training is especially important. The reviewer expressed concern for the feasibility of the approach but stated that the list of collaborators and coordination of partners somewhat addresses these concerns. The reviewer added that the high level of research and partnerships discussed in the proposal makes its success more likely, and the regional approach involving five states spreads benefits over a large area. The reviewer commented on the realistic maintenance and installation forecast that was provided but questioned whether the project has an Operations and Maintenance plan for EV infrastructure, in an effort to reduce range anxiety.

Question 3: Please comment on the project's progress and significant accomplishments to date.

Reviewer 1:

The reviewer found that the project has already demonstrated tangible progress, specifically with the installation of hundreds of EV chargers, delivery of EVs, training of the local workforce, and by assembling the EV Infrastructure Working Group.

Reviewer 2:

The reviewer stated that the fact that this project was able to get BEVs in today's market is very impressive.

Reviewer 3:

The reviewer observed that, despite supply chain issues, the project team has deployed over 10 vehicles in a short period of time and has conducted an impressive number of engagement events already; on the charging infrastructure side, the project has made significant progress in identifying the appropriate technology and locations for their deployments. The reviewer noted that the workforce training group has been established to help ensure that these communities are able to not only have service and installation provided for vehicles/EVSE but that they are not left behind in the transition to EVs more broadly.

Reviewer 4:

The reviewer noted that, in less than a year, the project is 15% complete with over half of the EVs reserved and/or received. The reviewer added that the identification of EVSE sites provided by the EV infrastructure working group is an important step, and EV outreach, demonstrations, and information exchanges are ongoing to increase the public's interactions with EVs. The reviewer stated that this project is off to a good start and appears to have good momentum moving forward.

Question 4: Please comment on the level of collaboration within the project team and the degree to which the project team has identified and leveraged the proper connections to achieve its project goals.

Reviewer 1:

The reviewer found it to be very impressive that the project lists a huge group of leads and partners with great diversity in terms of geography, interest, and backgrounds.

Reviewer 2:

The reviewer commented on the very impressive team including a number of Clean Cities coalitions.

Reviewer 3:

The reviewer stated that the number of partners engaged in this project is wide-reaching in both geography and project scope. The reviewer added that this project touches the vehicle and charging side and will depend on a large group of stakeholders to be engaged throughout. Based on the accomplishments to date, the reviewer found the network and partnerships created in this project to be vast and seemingly quite invested in its success.

Reviewer 4:

The reviewer noted that the project provided good detail on partners and their involvement in the project organization chart and project accomplishments and added that established efforts such as the EV infrastructure working group and workforce training group are very important and point to high levels of collaboration and coordination.

Question 5: Please provide comment on the contribution of this project to energy equity and environmental justice by ensuring the project benefits underserved and overburdened communities and does not cause increased burdens to these communities.

Reviewer 1:

The reviewer stated that the project has great potential equity contributions on its face, and the team has done an excellent job of highlighting them in the presentation.

Reviewer 2:

The reviewer commented that the Appalachian Region Commission is certainly in need of help in the economic realm and this project addresses this on several fronts.

Reviewer 3:

The reviewer noted that the majority of funding is going to rural communities and transit agencies that serve them; the project is inherently serving underserved communities, but the project team is also providing funding to 34 organizations that represent underserved communities. The reviewer stated that the project is also prioritizing creating jobs in the clean energy sector, which is one that will be crucial in this part of the country that has historically served our fossil-fuel-powered society.

Reviewer 4:

The reviewer found that this project provides a comprehensive regional approach to increasing engagement with EVs at all levels, including public ownership, workforce development, and charging accessibility in historically underserved areas. The reviewer appreciated that the project involves community outreach, education, and training and noted that project organizers have made efforts to engage communities at all levels of the project and aim to gather data to inform efforts in rural areas elsewhere.

Presentation Number: TI147
Presentation Title: Affordable Mobility Platform
Principal Investigator: Connor Herman (Forth Mobility)

Presenter
Connor Herman, Forth Mobility

Reviewer Sample Size
A total of three reviewers evaluated this project.

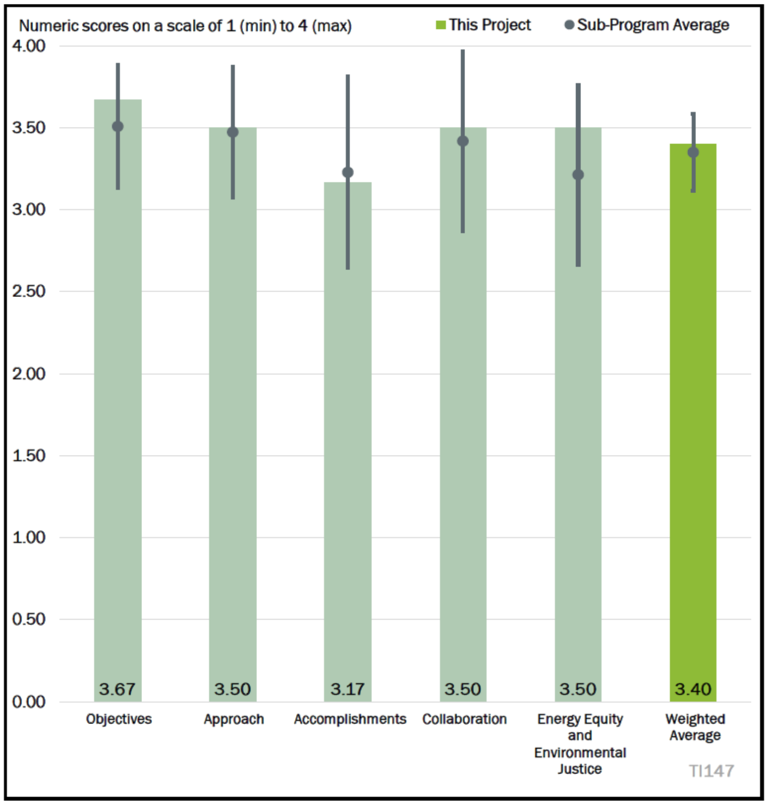

Figure 6-22 - Presentation Number: TI147 Presentation Title: Affordable Mobility Platform Principal Investigator: Connor Herman (Forth Mobility)

Question 1: Please provide comments on this project's degree of support for the overall Technology Integration (TI) objectives of improving fuel diversity, increasing local resiliency, and reducing greenhouse gas emissions through increasing alternative fuel use and transportation efficiency.

Reviewer 1:

The reviewer stated that the project objectives are clearly defined and well aligned with the TI goals; specifically, the project will contribute to the TI goals of improving fuel diversity, increasing local resiliency, and reducing GHG emissions.

Reviewer 2:

The reviewer commented that this project has a unique and very relevant set of objectives which directly relate to the TI objectives of improving fuel diversity, increasing local resiliency, and reducing GHG emissions. The reviewer added that the project focuses on developing replicable models for deploying shared vehicles and car sharing technology which also benefit local community members.

Reviewer 3:

The reviewer noted that getting car share programs going in low-income communities is a big lift, and they seem to have a plan.

Question 2: Please comment on this project's approach for integrating advanced transportation technologies and practices to solve real-world challenges.

Reviewer 1:

The reviewer indicated that a strength of this project is that it incorporates land-use in the implementation of transportation technology and incorporates clever and novel strategies for improving access to clean transportation.

Reviewer 2:

The reviewer stated that the project approach is very holistic, logical, and detailed, and describes the steps that would be needed to accomplish the project objectives. The reviewer added that the project team should definitely engage the U.S. Department of Housing and Urban Development (HUD) to determine how they could leverage HUD efforts to support EV charging infrastructure and transportation needs at affordable housing sites.

Reviewer 3:

The reviewer noted that they seem to be a bit slow on the start and expressed hope that they can pick up the pace. The reviewer recommended that they get the housing authorities involved sooner rather than later.

Question 3: Please comment on the project's progress and significant accomplishments to date.

Reviewer 1:

The reviewer found that the presentation indicates good progress with some milestones complete and many in progress.

Reviewer 2:

The reviewer observed that many of the BP 1 milestones have either been completed or are estimated to be completed by July 2023, and this was the most active phase of the project.

Reviewer 3:

The reviewer stated that they need to identify locations for parking the vehicles because parking spaces in cities are at a premium and many folks do not want to give up spaces for dedicated EVs.

Question 4: Please comment on the level of collaboration within the project team and the degree to which the project team has identified and leveraged the proper connections to achieve its project goals.

Reviewer 1:

The reviewer noted very detailed information on collaboration and coordination with project partners and appreciated the table that describes the objectives of communication, the frequency, and the ownership.

Reviewer 2:

The reviewer observed that the project has a complex set of team members across 11 different locations and found that they described very structured and detailed points of collaboration, modes, and participation across various aspects of the project, e.g., budget, project management, etc. The reviewer suggested that the project team consider engaging public sector housing agencies (federal, state, and local) and local green banks to support their efforts.

Reviewer 3:

The reviewer observed that only one Clean Cities coalition is involved, but connections have been made in 11 cities so it would be important to reach out to any coalitions in those cities. The reviewer added that it looks like they will be working with coalitions yet to be identified.

Question 5: Please provide comment on the contribution of this project to energy equity and environmental justice by ensuring the project benefits underserved and overburdened communities and does not cause increased burdens to these communities.

Reviewer 1:

The reviewer found that the project design is oriented around equity and does so in a novel way by coordinating transportation technology with land use. The reviewer added that the presentation comprehensively describes contributions to equity by outlining direct benefits to DACs.

Reviewer 2:

The reviewer stated that the project has outlined very clear energy and environmental justice benefit categories and suggested that the project team could consider also documenting how the car sharing models could help underserved communities build wealth.

Reviewer 3:

The reviewer observed that the project team is planning to reach out to housing authorities with certain income criteria and noted that it will be important to educate the managers of the identified housing complexes on the benefits of EVs.

Presentation Number: TI148
Presentation Title: Upper Midwest Inter-Tribal Electric Vehicle (EV) Charging Community Network
Principal Investigator: Robert Blake (Native Sun Community Power Development)

Presenter

Robert Blake, Native Sun Community Power Development

Reviewer Sample Size

A total of four reviewers evaluated this project.

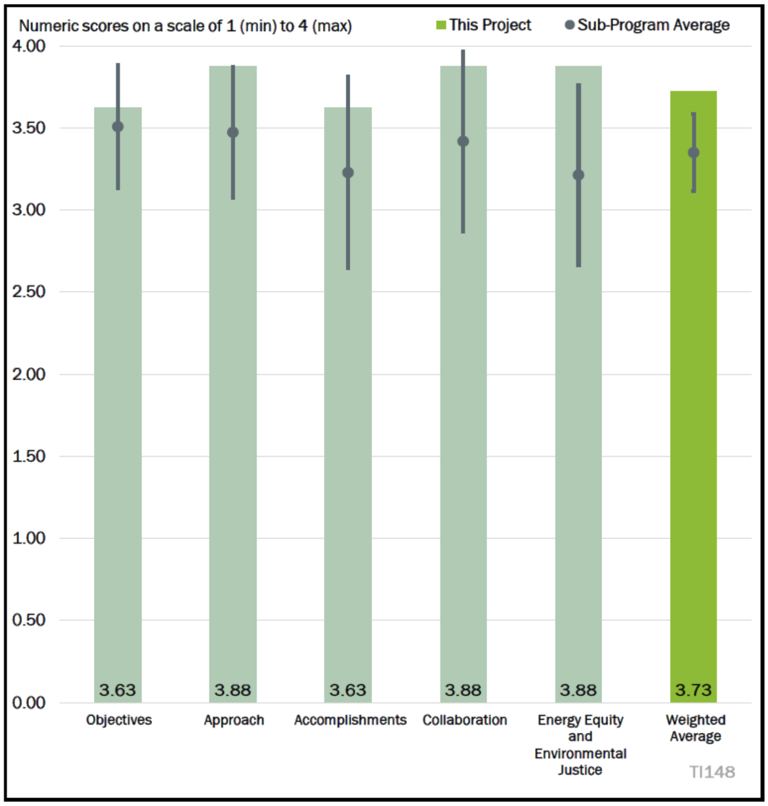

Figure 6-23 - Presentation Number: TI148 Presentation Title: Upper Midwest Inter-Tribal Electric Vehicle (EV) Charging Community Network Principal Investigator: Robert Blake (Native Sun Community Power Development)

Question 1: Please provide comments on this project's degree of support for the overall Technology Integration (TI) objectives of improving fuel diversity, increasing local resiliency, and reducing greenhouse gas emissions through increasing alternative fuel use and transportation efficiency.

Reviewer 1:

The reviewer commented that this is a fantastic project that aligns with TI goals through improving fuel diversity, local resiliency, and reducing GHG emissions within a novel context in northern tribal communities.

Reviewer 2:

The reviewer stated that the project team is pursuing TI objectives of improving fuel diversity, increasing local resiliency, and reducing GHGs, by leveraging real world data and lessons learned from Tribal communities. The reviewer noted that they are also developing, demonstrating, and deploying a replicable program for expanding clean and sustainable electrified transportation to underserved communities through EVs and EVSE deployment, data analysis, education, and outreach. The reviewer observed that they are testing out different types of EVs and chargers on tribal lands and sites in cold and harsh winter conditions, a very exciting and relevant project with high replicability potential.

Reviewer 3:

The reviewer commented that the introduction of EVs and infrastructure will go a long way to improve fuel diversity based on the fact that gasoline is very expensive on the reservation and many residents do not have resources to maintain internal combustion engine (ICE) vehicles.

Reviewer 4:

The reviewer stated that this project is wide-reaching in both geographic and project scope, and it will support the TI objectives of improving fuel diversity and increasing local resiliency by building systems from within communities to prepare for EV adoption in the future. The reviewer added that the project will directly lead to increased alternative fuel use via the deployment of EVs and EV charging stations for organizations that serve the community and noted that it is also focused on providing solutions and reducing barriers to EVs that are suitable for remote cold-weather environments.

Question 2: Please comment on this project's approach for integrating advanced transportation technologies and practices to solve real-world challenges.

Reviewer 1:

The reviewer stated that the project approach is wide-ranging and ambitious. The reviewer appreciated the fact that this project is demonstrating the viability of clean transportation technologies in two unique settings: cold climates, and Tribal communities.

Reviewer 2:

The reviewer observed that the project team seems to be on track to meet the BP 1 milestones; all their site locations have been determined, their fleets have confirmed participation in the transportation needs assessments, and more than 75% of the planned publicly available L2 EVSE on Red Lake and Standing Rock are expected to be installed and operational by the end of May 2023. The reviewer noted that the availability and scarcity of EVs, EVSE supply chain delays, and recent price increases pose challenges and barriers for project.

Reviewer 3:

The reviewer commented that the installation of DCFCs in critical locations will enable locals to go the long distances for services found on the reservation.

Reviewer 4:

The reviewer noted that this project relies on multiple partnerships that span the energy economy as well as those that will be most impactful to its success on the ground, and these partnerships will be pivotal for the project's success during the funded project period, while also creating opportunities for continued collaboration, learning, and development beyond the life of the grant. The reviewer stated that one of the project goals is to determine how much money can be saved by switching to EVs from combustion vehicles; also of note is that the project will be providing much-needed job training in these communities to ensure they are not left behind in this transition.

Question 3: Please comment on the project's progress and significant accomplishments to date.

Reviewer 1:

The reviewer noted that the project is in its early stages with a few milestones completed and more expected in the near term.

Reviewer 2:

The reviewer observed that all of their site locations have been determined, their fleets have confirmed participation in the transportation needs assessments, and more than 75% of the planned publicly available L2 EVSE on Red Lake and Standing Rock are expected to be installed and operational by the end of May 2023.

Reviewer 3:

The reviewer stated that half of the BP 1 milestones have been completed and the rest are close. The reviewer commented that the fact that they have branded this project with a common logo has given this project a positive spin.

Reviewer 4:

The reviewer found that the project is on track to meet its deliverables and has made significant progress already in the first BP. The reviewer noted that the project is supported by a tremendous number of partners that have buy-in to its success. Despite supply chain issues that might create delays outside of their control, the reviewer indicated that the project team seems well-equipped to stay on track in meeting its milestones.

Question 4: Please comment on the level of collaboration within the project team and the degree to which the project team has identified and leveraged the proper connections to achieve its project goals.

Reviewer 1:

The reviewer noted that the project team is collaborating with a very diverse (in terms of backgrounds, skillsets, and geography) set of partners including Tribal Nations, utilities, government agencies, and nonprofits.

Reviewer 2:

The reviewer commented that the project team described coordination and collaboration across three states, multiple tribes and reservations, public and private sector organizations, and added that the project team has a lot of support from Minnesota Department of Transportation (MnDOT) and the Minnesota governor and participated on the governor's workforce board of directors. The reviewer noted that there has also been an effort to sign virtual power purchase agreements with MnDOT to further the goal of reducing GHGs.

Reviewer 3:

The reviewer observed that it is important that Tribal leadership in the various nations are able to work together on this project and they have appeared to do this. The reviewer added that the utilities are on board, which is important when infrastructure involves DCFC units.

Reviewer 4:

The reviewer reiterated that the project's foundation is through partnerships and its teaming arrangements. The reviewer added that the project will leverage a number of funding sources to amplify its efforts and is coordinating effectively with other agencies with complementary programs (such as NEVI funding administered via State governments).

Question 5: Please provide comment on the contribution of this project to energy equity and environmental justice by ensuring the project benefits underserved and overburdened communities and does not cause increased burdens to these communities.

Reviewer 1:

The reviewer noted that the equity benefits of the project largely go without saying, although the team comprehensively describes those benefits in the presentation. The team highlights equity benefits such as including Tribal communities in the energy transition, promoting workforce development in Tribal communities, improving resiliency in Tribal communities, and providing access to clean transportation options in Tribal communities.

Reviewer 2:

The reviewer observed that the project is actively integrating the programs and technology into efforts that will provide tangible benefits for communities, including fleets for Family and Children Services, agriculture, Tribal college, buses for culture and language immersion school, and community shuttle service, workforce training, and legal agreements that could be utilized by other tribes.

Reviewer 3:

The reviewer noted that this project serves tribes on various reservations which will provide energy security for folks on the reservations identified on this grant.

Reviewer 4:

The reviewer stated that this project's core focus is on serving under-resourced and underserved Tribal communities. The reviewer added that it also features collaboration across several of these communities to create an "Electric Nation" so that these communities can pool their resources and work together toward shared goals and objectives. The reviewer observed that by creating partnerships early-on and securing buy-in on the plan, this project should avoid the increased burden that might otherwise be a threat or concern for this type of work.

Presentation Number: TI149
Presentation Title: Equitable Mobility Powering Opportunities for Workplace Electrification Readiness (EMPOWER)
Principal Investigator: Michael Graham (Western Washington Clean Cities)

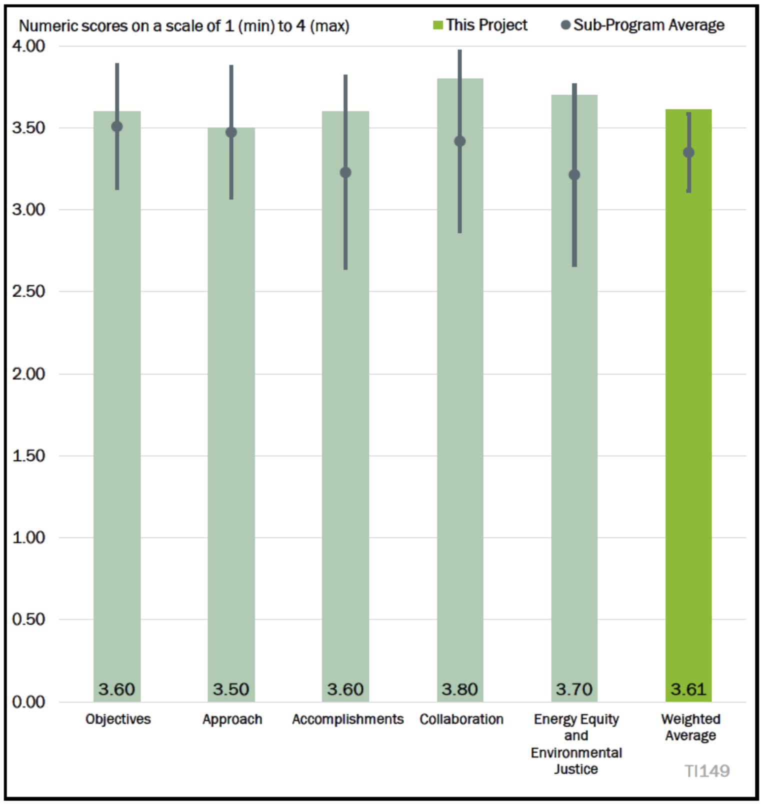

Figure 6-24 - Presentation Number: TI149 Presentation Title: Equitable Mobility Powering Opportunities for Workplace Electrification Readiness (EMPOWER) Principal Investigator: Michael Graham (Western Washington Clean Cities)

Presenter

Michael Graham, Western Washington Clean Cities

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Please provide comments on this project's degree of support for the overall Technology Integration (TI) objectives of improving fuel diversity, increasing local resiliency, and reducing greenhouse gas emissions through increasing alternative fuel use and transportation efficiency.

Reviewer 1:

The reviewer expressed the view that the focus on increasing workplace charging will be essential for accelerating transportation electrification and expanding access to individuals who do not have access to at home charging. The reviewer stated that if employees (and particularly lower- and middle-income individuals) see chargers at work, they may become more interested in EVs. Workplace charging is also essential to utilizing more renewable/photovoltaic generation during the day.

Reviewer 2:

The reviewer found that the project does attend to the TI goals related to fuel diversity and GHG reduction.

Reviewer 3:

The reviewer noted that the project seeks to accelerate interest and support for workplace charging to advance EV adoption that will reduce petroleum use and GHG emissions, supporting TI subprogram goals to improve fuel diversity, greater adoption of EVs and reduced use of petroleum transportation fuel. The reviewer added that the project will increase local resiliency by reducing peak time charging of EVs through daytime charging at the workplace and will reduce GHG emissions by increasing alternative fuel use in the consumer sector.

Reviewer 4:

The reviewer stated that this project directly addresses one of the major barriers to EV adoption, namely insufficient access to home charging. The reviewer noted that the workplace is the second-most used parking spot for most vehicles, in terms of time, and increasing access to charging at work will encourage more people to purchase and drive EVs for their daily commutes.

Reviewer 5:

The reviewer commented that the project appears to have met all of its milestones to date from what the presenter has indicated.

Question 2: Please comment on this project's approach for integrating advanced transportation technologies and practices to solve real-world challenges.

Reviewer 1:

The reviewer noted that the project focuses on the very real challenge of access to chargers for individuals who do not have access to at-home chargers and added that promoting workplace charging is also essential for aligning charging with renewable generation and grid capacity available during the day.

Reviewer 2:

The reviewer stated that the approach is good for coordinating with workplaces to establish charging.

Reviewer 3:

The reviewer commented that the approach is strong and in three phases: planning and preparing for implementation by developing resources, launching resource site, and training Clean Cities for outreach. The reviewer added that implementation of outreach would occur by contacting employers to share information around workplace charging and collect workplace charging installation commitments. The approach also includes wrap-up of implementation, project reflection, lessons-learned dissemination, and succession planning.

Reviewer 4:

The reviewer noted that contacting employers to share information around workplace charging and collect workplace charging installation commitments, while also establishing an online resource center for employers and the public is a great approach. The reviewer stated that the presentation did not give a lot of specific information on how employers would be approached or recruited by the coalitions, or what resources would be available on the website, but found that the site itself is easy to navigate and provides answers to a lot of common questions, as well as a good bit of technical information relative to the benefits of workplace charging.

Reviewer 5:

The reviewer stated that this type of project lends itself to integrating advanced transportation technologies and allows straightforward activities to solve real-world challenges.

Question 3: Please comment on the project's progress and significant accomplishments to date.

Reviewer 1:

The reviewer noted that the project is on track. It has completed or nearly completed all BP 1 milestones and has already received 13 commitments and completed two installations.

Reviewer 2:

The reviewer found the resource center and the Energy and Environmental Justice Action Plan (EEJ Action Plan) to be helpful documents but is looking forward to more actionable results in the near future.

Reviewer 3:

The reviewer noted that the first two workplace charger commitments have been secured by partner Virginia Clean Cities, and a bonus is that these meet Energy Environmental Justice metrics for the project. The reviewer observed that the project team completed a project wide EEJ Action Plan, launched a workplace charging resource center landing page (https://www.workplacecharging.com), and formally kicked off the outreach implementation phase. The reviewer noted that the team has trained 30 Clean Cities Coalition Implementation

Partners on engagement with workplaces, including providing technical assistance, and finalized a project-wide outreach flyer, market barriers report, and project evaluation plan. The reviewer added that all the project partners contracting is completed.

Reviewer 4:

The reviewer observed that the workplace charging website has already been launched and is available to the public to act as a resource center while the rest of the project is being implemented. With 2 years remaining in the timeline, 30% of the project objectives have been achieved.

Reviewer 5:

The reviewer commented that, from the oral presentation and the PowerPoint slides, it appears the project is meeting its milestones in accordance with the project plan.

Question 4: Please comment on the level of collaboration within the project team and the degree to which the project team has identified and leveraged the proper connections to achieve its project goals.

Reviewer 1:

The reviewer noted that there is a good group of project partners, and having East Tennessee Clean Fuels as a super prime is a good strategic decision because of the lack of EVs in the state (the project can bring awareness) and the rural communities/low income/underserved communities. The reviewer added that states further along the EV adoption path can serve as good peer learning/sharing for other partners.

Reviewer 2:

The reviewer commended the project team on a great partnership established to cover several different stakeholders in numerous locations.

Reviewer 3:

The reviewer stated that there is a very strong team assembled that includes Columbia-Willamette Clean Cities (prime), 30 Clean Cities coalitions across the country, East Tennessee Clean Fuels, Geaux Green, Shift2Electric, Smart Electric Power Alliance, Cerritos College, Center for Sustainable Energy (CSE) and The Cadeo Group. The reviewer noted that this team can cover all aspects of the project.

Reviewer 4:

The reviewer observed that this project includes 30 Clean Cities coalitions as partners, the largest assemblage of coalitions on a single VTO project. The reviewer stated that the project should be able to capitalize on existing coalition relationships with employers of all sizes, across the entire country and added that the project partners include a diverse array of industry and education stakeholders, making a strong core team.

Reviewer 5:

The reviewer noted that the communications plan that drives the collaboration and coordination effort is in place and appears to be working according to plan.

Question 5: Please provide comment on the contribution of this project to energy equity and environmental justice by ensuring the project benefits underserved and overburdened communities and does not cause increased burdens to these communities.

Reviewer 1:

The reviewer stated that the broad definition of EEEJ is meant to ensure that important communities will not be left behind due to specific, narrow EJ criteria; offering communities the possibility to explain why they should be considered EJ is a valuable approach.

Reviewer 2:

The reviewer commented that the guide is a great first step; looking forward to next steps and rollout of this strategy.

Reviewer 3:

The reviewer summarized that the EEEJ aspects of this project focus project work in communities subjected to historical disinvestment and overburdened with pollution in 30 Clean Cities coalition locations. The project outlines how it aligns with the Justice40 Initiative. The Clean Cities coalitions that are part of the EMPOWER project (listed from West Coast to East Coast) are: Long Beach Clean Cities, East Bay Clean Cities Coalition, San Diego Regional Clean Cities Coalition, Columbia-Willamette Clean Cities, Western Washington Clean Cities, Utah Clean Cities, Drive Clean Colorado, North Dakota Clean Cities, Minnesota Clean Cities, Wisconsin Clean Cities, Illinois Alliance for Clean Transportation, Drive Clean Indiana, Michigan Clean Cities, Central Oklahoma Clean Cities, Tulsa Clean Cities, Dallas-Fort Worth Clean Cities, Louisiana Clean Fuels, Central Florida Clean Cities Coalition, Clean Cities-Georgia, East Tennessee Clean Fuels Coalition, Kentucky Clean Fuels Coalition, Virginia Clean Cities, State of West Virginia Clean Cities, Greater Washington Region Clean Cities Coalition, State of Maryland Clean Cities, New Jersey Clean Cities, Empire Clean Cities, Connecticut Southwestern Area Clean Cities, Vermont Clean Cities, Granite State Clean Cities Coalition, and Maine Clean Communities.

Reviewer 4:

The reviewer noted that the project team has completed a project wide EEJ Action Plan, which focuses project work in communities subjected to historical disinvestment and overburdened with pollution, and outlines how the project defines equity for 40% goal, aligning with the Justice40 Initiative. The reviewer added that, of 13 workplace charging commitments so far, five meet EEJ metrics of the project, which shows a good mix and a determined effort to include EEJ considerations in the program.

Reviewer 5:

The reviewer commented that this project appears to have a well-organized EEJ Action Plan, and with the variety of project locations/partners, the EEJ Action Plan should have access to a variety of locations that are good areas to apply the plan.

Presentation Number: TI150
Presentation Title: Charge to Work USA
Principal Investigator: Jason Zimbler (CALSTART)

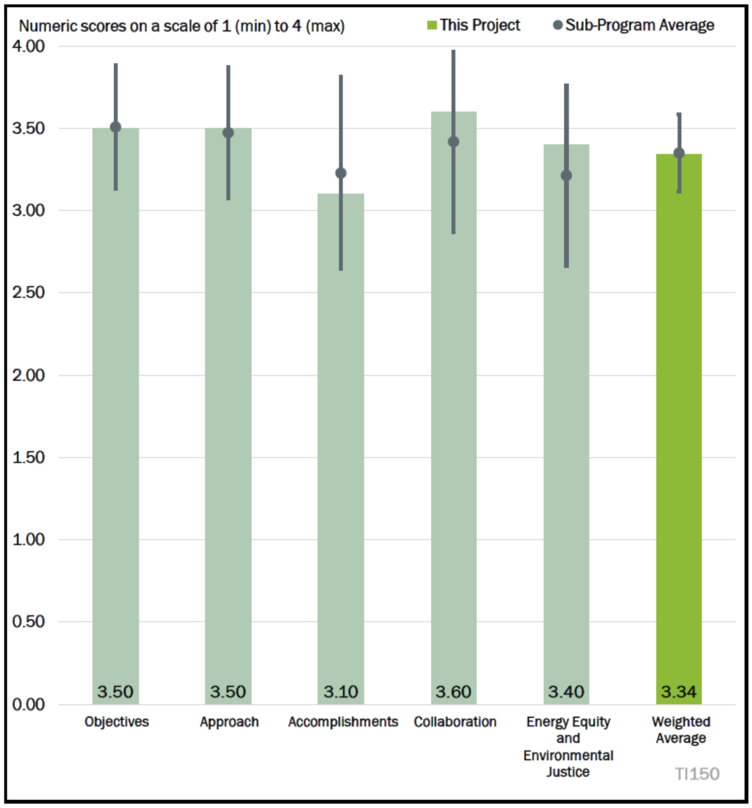

Figure 6-25 - Presentation Number: TI150 Presentation Title: Charge to Work USA Principal Investigator: Jason Zimbler (CALSTART)

Presenter

Jason Zimbler, CALSTART

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Please provide comments on this project's degree of support for the overall Technology Integration (TI) objectives of improving fuel diversity, increasing local resiliency, and reducing greenhouse gas emissions through increasing alternative fuel use and transportation efficiency.

Reviewer 1:

The reviewer stated that the focus on workplace charging is important for utilizing available grid assets/resources without increasing costs by increasing daytime charging. Further, it will raise visibility of EVs and could spur greater adoptions providing access to those without at home charging options.

Reviewer 2:

The reviewer found that the goals of this project align with multiple TI goals.

Reviewer 3:

The reviewer stated that the project objectives are to gain greater EV adoption by enhancing driver confidence in charger availability, as well as to increase reliability and geographic coverage of charging infrastructure through the adoption of workplace charging solutions, thus reducing range anxiety, and increasing consumer confidence. Additionally, the objectives are to reduce GHG emissions; expand access to electric mobility in DACs and workplaces in DACs; adopt charging solutions for employees that do not have access to charging at home; increase local resiliency and reduce GHG emissions; and create a self-sustaining market for workplace charging.

Reviewer 4:

The reviewer commented that improved access to workplace charging is an excellent way of supporting TI goals of increasing alternative fuel use and transportation efficiency and added that this project has ambitious goals for the number and sizes of employers expected to make workplace charging commitments.

Reviewer 5:

The reviewer found that the TI tasks seem to be on track with the grant milestones.

Question 2: Please comment on this project's approach for integrating advanced transportation technologies and practices to solve real-world challenges.

Reviewer 1:

The reviewer commented that state segmentation with primes is good and commended the focus on the prime's strengths and aim to avoid duplication. The reviewer added that the interactive portal is a great option, and the scenario element will be very helpful as site hosts weigh and evaluate options. The reviewer further stated that the project approach, given its specific objectives, is good. The reviewer questioned whether the conversion rate would increase if there was implementation funding, and wondered how binding an employer commitment is.

Reviewer 2:

The reviewer stated that it is a solid approach with great partners with appropriate goals.

Reviewer 3:

The reviewer indicated that the approach is for CALSTART and Forth Mobility to collaborate to develop a brand and strategic vision; launch a Workplace Resource Center; develop an Implementation Portal; create strategic outreach and marketing plans; and obtain early commitments from employers and public officials to participate in the program.

Reviewer 4:

The reviewer noted that the project approach is multi-faceted, including direct outreach to employers, an online resource website, and a push to create a self-sustaining market for workplace charging. The reviewer found this to be an important key for long-term success of workplace charging initiatives. The reviewer noted that the project team includes relatively few Clean Cities coalitions, whereas other similar projects are including a large number of coalitions, across multiple geographic regions, to leverage their local knowledge in recruiting employers.

Reviewer 5:

The reviewer stated that the integration of advanced transportation technology involved in the grant appears to be in line with the goals of the grant. The reviewer added that the final results of the project will determine the success of this part of the grant; it is too early to tell how successful this part of the program will be.

Question 3: Please comment on the project's progress and significant accomplishments to date.

Reviewer 1:

The reviewer noted that the project had some challenges getting started so they are behind in meeting milestones, but it appears they have laid the foundation to get back on track for remaining BPs.

Reviewer 2:

The reviewer stated that the project is set up for success but looking forward to additional progress.

Reviewer 3:

The reviewer commented that the accomplishments include public events and appearances at Forth Mobility's 2022 Roadmap Conference; coordinating and preparing materials for a remote webinar and two in-person events; a workplace charging educational webinar for National Grid NY's commercial customers in Spring 2023 as well as the Climate Group's US Climate Action Summit and Forth Mobility's Roadmap conference in April/May 2023; and collaborating on a unified message for Charge@Work, a single, public-facing workplace charging campaign and assistance program. The reviewer noted that CALSTART and Forth Mobility have chosen a final logo and have completed a full brand guide and are working collaboratively to effectively segment employers throughout the country. In addition, CALSTART is finalizing its strategy for employer recruitment and has developed an introductory list of targets for the first round of outreach, and the Workplace Charging Resource Center and Implementation Portal have been completed.

Reviewer 4:

The reviewer noted that, with 15 days left in BP 1, the presentation listed all the milestones as being in-progress and overall project objectives as being 30% complete. The reviewer commented that the listed accomplishments outline a lot of strategizing, finalizing, and identifying of “warm” targets, but few concrete steps outside of one conference presentation and three webinars given, along with completion of a branding guide. The reviewer added that the Charge@Work website mentioned in the presentation is up and running and includes a good amount of resources, along with some well-crafted pitches to solicit employer commitments and the project has spent only a small portion of its total budget, which seems commensurate with the level of achievements accomplished to date.

Reviewer 5:

The reviewer indicated that, based on the project manager presentation and the PowerPoint presentation, it appears the accomplishments and progress are in line with the project goals, and seem to be in line with the milestones, but it is too early to tell for sure.

Question 4: Please comment on the level of collaboration within the project team and the degree to which the project team has identified and leveraged the proper connections to achieve its project goals.

Reviewer 1:

The reviewer commended the project team, saying collaboration and partners are excellent and utility involvement is great.

Reviewer 2:

The reviewer stated that it is a great team with the right expertise to make this project successful.

Reviewer 3:

The reviewer noted a very strong team assembled to complete the project. The lead organization are CALSTART/Forth Mobility with partner organizations, EVNoire, Climate Group, NESCAUM, Empire Clean Cities, EP-ACT, Pittsburgh Region Clean Cities, Drive Clean Colorado, Northern Colorado Clean Cities, Qmerit, ZappyRide, National Grid, Edison Electric Institute and EVgo. The reviewer noted that this a very strong group and should be able to accomplish the project successfully and added that the meeting schedules and collaboration are working well.

Reviewer 4:

The reviewer indicated that project leadership has held alignment calls with Co-Prime Forth Mobility on a weekly basis, separate weekly calls with EVNoire, Climate Group, and ZappyRide, monthly calls with National Grid, and ad hoc meetings with other sub-recipients to work through contracting agreements. The reviewer noted that Forth Mobility and CALSTART are co-prime organizations in both TI150 and TI151, programs with very similar objectives and approaches, and are jointly developing Charge@Work, a unified, national campaign promoting workplace charging, to be used as pillars of both projects. The reviewer commented that it will be interesting to see how these two projects keep their efforts separate, and how they tally up their recruited companies, etc., to avoid the appearance of delivering the same results to fulfill two contracts.

Reviewer 5:

The reviewer stated that collaboration and coordination appear to be in line with the project’s milestones.

Question 5: Please provide comment on the contribution of this project to energy equity and environmental justice by ensuring the project benefits underserved and overburdened communities and does not cause increased burdens to these communities.

Reviewer 1:

The reviewer remarked on the good partners for EEEJ work.

Reviewer 2:

The reviewer is anticipating additional implementation in the project to put the agreed-upon EEEJ principles to work.

Reviewer 3:

The reviewer stated that CALSTART, EVNoire, and partners are actively incorporating diversity, equity, and inclusion (DEI) into the project objectives with these targets: 30% of employer sites located in underserved areas, 25% of workplace charging stations in underserved areas, 40% of Ride and Drives in underserved areas, 30% of business certifications in DEI areas and 30% of budget to minority- and women-owned business enterprises. The reviewer added that the project is meeting the EEEJ requirements by ensuring the project benefits underserved and overburdened communities and does not cause increased burdens to these communities, goals of the DOE/VTO.

Reviewer 4:

The reviewer cited the presentation as stating the following relative to EEEJ: CALSTART, EVNoire, and our partners are actively incorporating DEI into our project objectives with these targets: 30% of employer sites located in underserved areas, 25% of workplace charging stations in underserved areas, 40% of Ride and Drives in underserved area, 30% of business certifications in DEI areas, 30% of budget to minority- and women-owned business enterprises. The reviewer found these goals to be comprehensive and attainable but did not see specific language outlining collaboration with affected communities.

Reviewer 5:

The reviewer commented that the EEEJ section of the project appears to be doing well, based on the PowerPoint slides and the oral presentation. The reviewer added that a successful completion of this part of the grant will only be apparent once the project is finished and the report details are written.

Presentation Number: TI151
Presentation Title: Leadership of Employers for Electrification Program
Principal Investigator: Steffani Cuff (Forth Mobility)

Presenter

Aleksandra Evert, Forth Mobility

Reviewer Sample Size

A total of five reviewers evaluated this project.

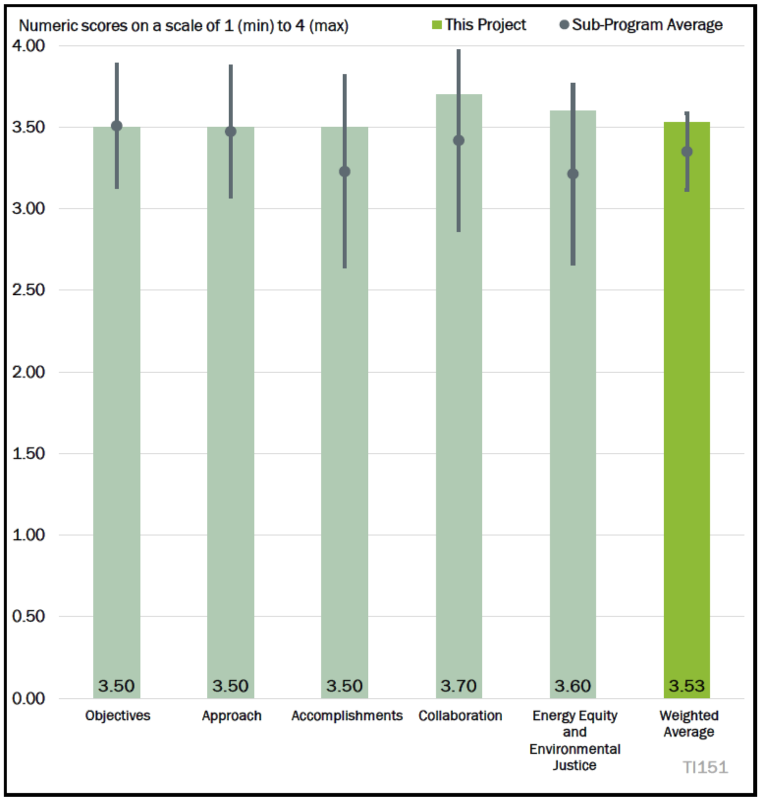

Figure 6-26 - Presentation Number: TI151 Presentation Title: Leadership of Employers for Electrification Program Principal Investigator: Steffani Cuff (Forth Mobility)

Question 1: Please provide comments on this project's degree of support for the overall Technology Integration (TI) objectives of improving fuel diversity, increasing local resiliency, and reducing greenhouse gas emissions through increasing alternative fuel use and transportation efficiency.

Reviewer 1:

The reviewer found that the focus on workplace charging is good and meets TI objectives. The reviewer noted that it is unclear how the employer registrations increase local resilience, but the education, outreach and technical assistance are good objectives.

Reviewer 2:

The reviewer noted that the project aligns well with the TI goals.

Reviewer 3:

The reviewer indicated that the project objectives are to develop and execute a nationwide workplace charging program comprised of education, outreach and technical assistance activities; gain over 2,500 employer commitments with the end goal of catalyzing over 20,000 EVSE port installations; reach 5,000 employer registrations on the Electric Vehicle Adoption Leadership (EVAL) certification platform; meet VTO goals by empowering local communities with the technical expertise to influence charging solutions at their workplaces through a tailored, regional outreach; enable a large-scale increase in workplace charging to accelerate EV adoption; and increase organizational capacity and community leadership to pursue workplace charging solutions. The reviewer indicated that this will also increase local resiliency and reduce GHG emissions.

Reviewer 4:

The reviewer commented that this project aims to develop and execute a nationwide workplace charging program comprised of education, outreach, and technical assistance activities. In addition, the project hopes to gain more than 2,500 employer commitments with the end goal of catalyzing at least 20,000 electric vehicle support equipment (EVSE) port installations and reach at least 5,000 employer registrations on the EVAL certification platform. The reviewer found that the objectives are valid and, if successful, the project should make a positive impact on the adoption of EVs. The reviewer noted that workplace charging will be a key component of addressing current barriers to EV adoption, and the project supports TI objectives of improving fuel diversity, increasing local resiliency, and reducing GHG emissions through increasing alternative fuel use and transportation efficiency.

Reviewer 5:

The reviewer stated that the project plan and milestones appear to be on schedule and, based on the presentation and PowerPoint, the project is on track with projective objectives.

Question 2: Please comment on this project's approach for integrating advanced transportation technologies and practices to solve real-world challenges.

Reviewer 1:

The reviewer stated that the project has ambitious goals and good partners to try to meet these goals. The reviewer questioned whether it will be feasible to reach the more than 2,500 commitments and more than 5,000 registrations. The reviewer noted that the regional aspect is good for reaching large numbers, however.

Reviewer 2:

The reviewer commented that it is an interesting approach to gain buy-in from a mass amount of stakeholders for workplace charging.

Reviewer 3:

The reviewer found the approach to be solid, starting with Initiation and Operations Planning. The project team will confirm participants for the Project Advisory Group and finalize program design; finalize implementation partners and issue contracts and plan localized outreach strategy; build out and launch the website; and lastly, host a full partner kickoff meeting and train implementation partners. According to the reviewer, this approach is a process for success.

Reviewer 4:

The reviewer stated that this project will encourage and incentivize workplaces to pursue a nationally recognized EVAL certification and found that this could be a valuable incentive for employer participation and a unique approach not shared with other similar VTO projects. Partners include Clean Cities Coalitions, non-governmental organizations (NGOs), electric utilities, nonprofits, and municipalities. The reviewer noted that, as entities that regularly interact with regional workplaces, implementation partners will work with lead sub-recipients and leverage their communication channels to recruit a wide sample size of businesses of all sizes, industry types, demographics, and geographies. The reviewer concluded that this is a solid plan that takes advantage of existing relationships of the project partners.

Reviewer 5:

The reviewer noted that it appears the integration of advanced transportation technology is on track, but the presentation does not really explain much in detail about the progress. The reviewer anticipates that next year's AMR will provide better definition of milestone completion.

Question 3: Please comment on the project's progress and significant accomplishments to date.

Reviewer 1:

The reviewer observed that many milestones are reaching completion and are scheduled to be completed several months ahead of the end of BP 1.

Reviewer 2:

The reviewer stated that this project is set up well for future successes.

Reviewer 3:

The reviewer outlined the accomplishments so far for the Leadership of Employers for Electrification Program (LEEP) Project. Forth Mobility consulting has finalized the implementation partners and currently has nine partners on contract, and they anticipate the remaining partners to be on contract by end of Q3; the certification program design is complete and in review with lead sub-recipients; the project advisory group has identified 12 members for the group and created an advisory specific communications plan which outlines meeting frequency, duration and other administrative expectations; Forth Mobility and Green Light Labs finalized the statement of work. Green Light Labs will serve as the technical advisor for Forth Mobility and is currently in the process of building out visual specifications for the website. The reviewer noted that the Charge@Work accomplishments include the branding and marketing campaign. Forth Mobility and CALSTART are jointly developing Charge@Work, a unified, national campaign promoting workplace charging. The reviewer commented that CALSTART and Forth Mobility created and agreed upon a final logo, completed a full brand guide, created a web landing page and secured the chargeatwork.org domain name; they also finalized Charge@Work Pledge to collect employer commitments and hosted a Charge@Work partner gathering at the 2023 Roadmap Conference in Portland, Oregon; Forth Mobility and CALSTART are working collaboratively to effectively segment employers throughout the country; Forth Mobility is finalizing its strategy for employer recruitment and has developed an introductory list of targets for the program.

Reviewer 4:

The reviewer noted that the project is still in BP 1 and has accomplished 15% of its overall project goals. Most BP 1 and BP 2 goals are in progress and on schedule.

Reviewer 5:

The reviewer stated that the presentation and PowerPoint slides indicate the project accomplishments/milestones have been made in a timely manner.

Question 4: Please comment on the level of collaboration within the project team and the degree to which the project team has identified and leveraged the proper connections to achieve its project goals.

Reviewer 1:

The reviewer commented on the great project partners but noted that it is unclear how this partnership with CALSTART differs from the Forth project. While the collaboration is good, the reviewer suggested that it would be beneficial for future reviews to clearly explain the uniqueness and delineation between the projects.

Reviewer 2:

The reviewer stated that this is a great team that sets up this project for success.

Reviewer 3:

The reviewer commented on the great team assembled, with no weak links. The reviewer summarized the project organization as follows: Forth Mobility is sharing prime responsibility with two other organizations, CALSTART and Columbia-Willamette Clean Cities Coalition. Forth Mobility and CALSTART make up the Charge@Work team. Each prime leads a core group of lead-subrecipients. Forth Mobility is responsible for the communication of the project including developing marketing assets and conducting a Northwest regionally focused outreach campaign. The reviewer noted that Plug In America, EVNoire and The Electrification Coalition bring a broad depth of experience working on transportation electrification projects nationwide, with special emphasis on consumer adoption. Partners include Clean Cities Coalitions, NGOs, electric utilities, nonprofits, and municipalities. The reviewer noted that, as entities that regularly interact with regional workplaces, implementation partners will work with lead sub-recipients and leverage their communication channels to recruit a wide sample size of businesses of all sizes, industry types, demographics, and geographies.

Reviewer 4:

The reviewer stated that, despite setbacks due to staff changes and learning to coordinate and collaborate across a three-prime effort, the project is on track. Forth Mobility and CALSTART are co-prime organizations in both TI150 and TI151, programs with very similar objectives and approach, and are jointly developing Charge@Work, a unified, national campaign promoting workplace charging, to be used as pillars of both projects. The reviewer expressed interest in seeing how these two projects keep their efforts separate, and how they tally up their recruited companies, etc. to avoid the appearance of delivering the same results to fulfill two contracts.

Reviewer 5:

The reviewer stated that, based on the presentation and PowerPoint slides, it appears the collaboration and coordination among the project team is ongoing and successful to date.

Question 5: Please provide comment on the contribution of this project to energy equity and environmental justice by ensuring the project benefits underserved and overburdened communities and does not cause increased burdens to these communities.

Reviewer 1:

The reviewer found that DEI has been integrated into the project’s decision-making processes and the focus on community partners in the EJ communities is fantastic. The reviewer praised the focus group to assess effectiveness of resources.

Reviewer 2:

The reviewer commented that it is clear the project team has taken the EEEJ component of this project seriously and will certainly align to EEJ principles throughout.

Reviewer 3:

The reviewer noted that the overall goal of the LEEP is to bring outreach, education and resources on EVs and charging access to employers and workers of all demographics; to advance DEI in all the project’s decision-making processes; and to understand the barriers to workplace charging that exist for low-income, BIPOC, rural and other underserved employers and employees. To increase access to clean commuting and create opportunities for historically underserved communities, the reviewer observed that Forth Mobility will develop community partnerships and listen and respond to expressed needs as LEEP is designed and implemented, to ensure that the program can scale while maintaining diverse, equitable and inclusive processes and outcomes.

Reviewer 4:

The reviewer found that the project has created a comprehensive EEEJ plan and has established several DEI Milestones to ensure the project is explicitly integrating DEI into its project management plan. The reviewer added that this project’s EEEJ plan is spelled out in more detail than most projects and noted that adding a timetable for accomplishing certain verifiable milestones does more than just pay lip service to the requirement.

Reviewer 5:

The reviewer stated that, at this point in the project, there does not seem to be much information about EEEJ activities. The reviewer anticipates that there will be a lot more about this area in next year’s AMR.

Presentation Number: TI152
Presentation Title: Project Sila: An Arctic CNG Pilot Test Program
Principal Investigator: Keith Patterson (ASRC Energy Services)

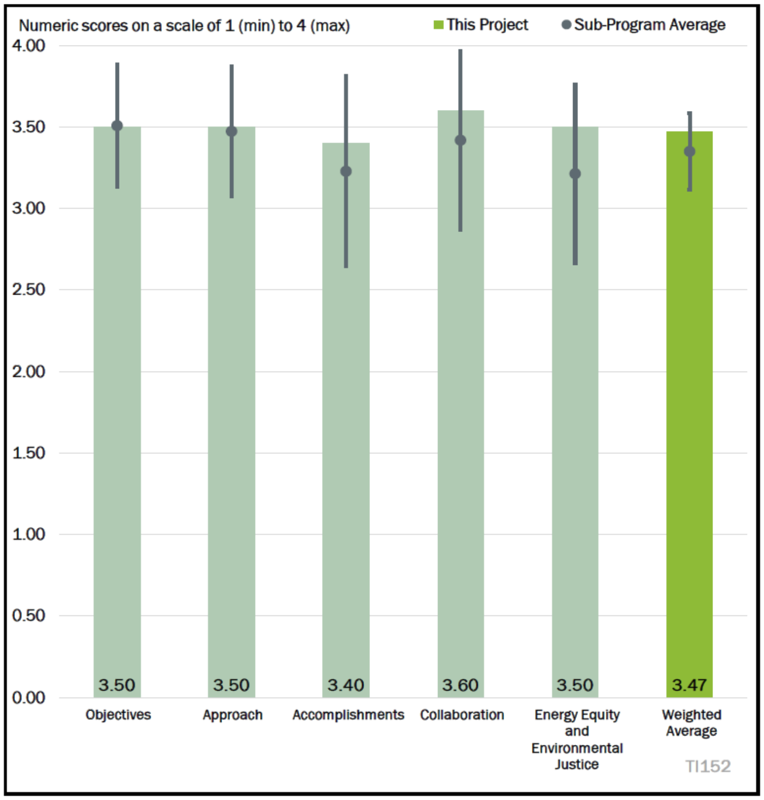

Figure 6-27 - Presentation Number: TI152 Presentation Title: Project Sila: An Arctic CNG Pilot Test Program Principal Investigator: Keith Patterson (ASRC Energy Services)

Presenter

Troy Tempel, ASRC Energy Services

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Please provide comments on this project's degree of support for the overall Technology Integration (TI) objectives of improving fuel diversity, increasing local resiliency, and reducing greenhouse gas emissions through increasing alternative fuel use and transportation efficiency.

Reviewer 1:

The reviewer stated that the project objectives consist of a pilot test of CNG-upfitted HD trucks and noted that the project team will install an Arctic rated CNG fueling station and benchmark CNG vs. diesel performance while measuring reduction in emissions. The reviewer noted that this improves fuel diversity by using a readily available and underutilized fuel source. The reviewer observed that this pilot project will document the feasibility of CNG operations in the Arctic and address concerns with using a high CO_2 local fuel source. Further, it will provide training to both operator and maintenance personnel on CNG operation, with the potential to deploy this technology to other parts of the North Slope.

Reviewer 2:

The reviewer found that the project is properly aimed at improving fuel diversity, increasing local resilience, and reducing GHG emissions and noted that, while developed for the Alaska market, the results could be applicable to other cold weather regions. In addition, this project is focused particularly upon operation in what could be considered a sensitive environmental area.

Reviewer 3:

The reviewer found this project to be excellent because it addresses all the TI objectives. The reviewer noted that replacing trucked-in diesel with locally sourced natural gas provides efficiencies not typical with natural gas projects, so this is particularly interesting and could have application to other locations in the U.S. where stranded gas is located and diesel equipment such as mining or drilling equipment is used.

Reviewer 4:

The reviewer stated that this project is unique and demonstrates key aspects of TI, supporting improved fuel diversity and local resiliency, based on the technology demonstrated.

Reviewer 5:

The reviewer commented that this project clearly improves fuel diversity, reduces GHGs through increasing alternative fuel use, and increases local resiliency. The reviewer did not find an improvement in transportation efficiency.

Question 2: Please comment on this project's approach for integrating advanced transportation technologies and practices to solve real-world challenges.

Reviewer 1:

The reviewer noted that the approach is to use off-the-shelf designs to ensure compressor design meets Arctic and CO_2 barriers. The reviewer observed that the site plan was drafted and needed to finalize with tie-in locations, and truck procurement was submitted with PAPE Kenworth in March 2023. Compressors will be tested, and staff training will occur at Onboard Dynamic's facility compressor installation. The reviewer concluded that this is a solid approach to this difficult project.

Reviewer 2:

The reviewer indicated that the project approach seems solid, with all the expected steps plus additional ones specifically recognizing the need for ensuring proper equipment operation and troubleshooting issues. The reviewer noted that the plan is for two years of operation and found this to be a better choice than a single year in this very challenging environment. The reviewer recommended having more of an outreach and education program to attempt to reach additional potential users.

Reviewer 3:

The reviewer commented that it is a relatively uncomplicated project, but the approach looks to be sound. The reviewer found value in addressing a barrier (cold weather) that has not been tackled before, and evaluating high CO_2 gas which may not have been an issue before and may not be an issue in too many places.

Reviewer 4:

The reviewer stated that this project demonstrates advanced transportation technologies and provides this technology to northern climate operators around the world where oil and gas extraction occurs.

Reviewer 5:

The reviewer noted that the project demonstrated the technology, ordered the technology, and plans to provide training and education on operating the technology, a great approach. The reviewer added that it takes a step back and shows, instead of tells, how great the technology is, and supports it through the purchasing and integration of this technology.

Question 3: Please comment on the project's progress and significant accomplishments to date.

Reviewer 1:

The reviewer noted that all compressors, trucks, and equipment have been ordered, and the project team is actively working with Onboard Dynamics on compressor design and the Arctic and CO_2 barriers. The project is on plan and budget.

Reviewer 2:

The reviewer stated that the project appears to largely be proceeding as planned, but the project has only been in place about a year, with the first year focused on equipment procurement, compressor design and location, and ordering the trucks. The reviewer noted that there have been some supply chain delays, but they are working through those. The reviewer added that a particular focus of activities to date has been addressing the high CO_2 content of the fuel, which can be a major issue for compression vendors and noted that the utility might add a large-scale scrubber if the project takes off.

Reviewer 3:

The reviewer commented that the project is still really getting underway, with no major issues identified at this point. It is on track.

Reviewer 4:

The reviewer stated that, based on the verbal presentation and PowerPoint slides this project is on track and meeting its milestone schedule.

Reviewer 5:

The reviewer observed that the project is on track to meet its goals.

Question 4: Please comment on the level of collaboration within the project team and the degree to which the project team has identified and leveraged the proper connections to achieve its project goals.

Reviewer 1:

The reviewer observed that the team is strong and has the appropriate acumen to have a successful project. The lead organization is ASRC Consulting & Environmental Services with LLC partners of Onboard Dynamics (CNG compression equipment), PAPE Kenworth (CNG trucks), Agility Fuel Systems (CNG truck upfitting), Norgasco, Inc. (natural gas utility community partners), and the Arctic Slope Regional Corporation.

Reviewer 2:

The reviewer noted that partners include the manufacturer of a unique-design compressor for this environment, the truck manufacturer, and the CNG storage system manufacturer, and the prime is providing the project management/integration and many of the technical assistance services, including monitoring operation. The reviewer observed that the team lead seems to have been working closely with the equipment suppliers to resolve technical barriers and they are hoping to expand the team, already working with the natural gas utility and, in the future, operations contractors.

Reviewer 3:

The reviewer stated that the project team members are experienced, and it appears that collaboration and coordination are proceeding well. The reviewer noted that the trucks have not been deployed yet, so the real test is coming later.

Reviewer 4:

The reviewer observed that project collaboration and coordination appear to be on track in an area that has a hostile weather environment.

Reviewer 5:

The reviewer commented that the project brought together key partners to achieve their goals.

Question 5: Please provide comment on the contribution of this project to energy equity and environmental justice by ensuring the project benefits underserved and overburdened communities and does not cause increased burdens to these communities.

Reviewer 1:

The reviewer noted that the Arctic Slope Regional Corporation consists of seven communities—Barrow, Wainwright, Atqasuk, Nuiqsut, Kaktovik, Pt. Lay, and Pt. Hope—three of which have natural gas sources. The reviewer added that they are all utilizing a local fuel source that will drastically reduce vehicle fueling costs and emission output. Currently, diesel is barged up seasonally. The reviewer noted that air quality will be further improved as commercial fleets transition to a CNG source.

Reviewer 2:

The reviewer found that the project provides for improvements related to energy and environment and added that the operation area now is an active oil operation zone, so air quality could be a concern and thus the benefit from greater use of this technology would be appreciated.

Reviewer 3:

The reviewer commented that this is a really unique project that has the potential to provide direct benefit to affected identified communities if the trucks and demonstration are successful. The reviewer added that the fact that they are using lower emitting trucks and displacing trucked in fuel is very beneficial.

Reviewer 4:

The reviewer stated that, based on the location of this project, it appears this project supports EEEJ requirements better than most of the other projects. The reviewer added that this project area is an example of an area that is underserved.

Reviewer 5:

The reviewer stated that offering communities the emissions and reliability data of this technology is great and indicated that it would be great to know if the project team has considered doing targeted education and outreach in tandem with providing this information, as well as which communities the team is prioritizing to receive that data.

Acronyms and Abbreviations – TI

Abbreviation	Definition
ACP50	Areas of concentrated poverty where 50% or more of residents are people of color
AFV	Alternative fuel vehicle
BEV	Battery electric vehicle
BIPOC	Black, indigenous, people of color
BP	Budget period
CBO	Community-based organization
COVID	Coronavirus disease (COVID-19), infectious disease caused by the SARS-CoV-2 virus
CNG	Compressed natural gas
CSE	Center for Sustainable Energy
DAC	Disadvantaged communities
DCFC	Direct current fast charger
DEI	Diversity, equity, and inclusion
DER	Distributed energy resources
DOE	U.S. Department of Energy
EEEJ	Energy equity and environmental justice
EEJ Action Plan	Energy Environmental Justice Action Plan
EERE	Energy Efficiency and Renewable Energy
EJ	Environmental Justice
EV	Electric vehicle(s)
EVAL	Electric Vehicle Adoption Leadership
EVSE	Electric vehicle supply equipment
GEM	Greenlink Equity Map
GHG	Greenhouse gas
H_2	Hydrogen
HBCU	Historically black colleges and universities
HD	Heavy-duty
HUD	U.S. Department of Housing and Urban Development
ICE	Internal combustion engine
L2	Level 2

Abbreviation	Definition
LEEP	Leadership of Employers for Electrification Program
LPG	Liquified petroleum gas or propane
MD	Medium-duty
MFH	Multi-family housing
NEVI	National Electric Vehicle Infrastructure
NFPA	National Fire Protection Association
NGO	Non-government organization
NGV	Natural gas vehicle
NREL	National Renewable Energy Laboratory
OEM	Original equipment manufacturer
RDD&D	Research, development, deployment and demonstration
RNG	Renewable natural gas
SCAQMD	South Coast Air Quality Management District
TCO	Total cost of ownership
TI	VTO Technology Integration subprogram
USDA	U.S. Department of Agriculture
VoICE-MR	Vocation Integrated Cost Estimation for Maintenance and Repair
VTO	Vehicle Technologies Office
WVU	West Virginia University

7. Vehicle Analysis

The Vehicle Technologies Office (VTO) supports research, development, demonstration, and deployment (RDD&D) of new, efficient, and clean mobility options that are affordable for all Americans. The office's investments leverage the unique capabilities and world-class expertise of the national laboratory system to develop new innovations in vehicle technologies, including: advanced battery technologies; advanced materials for lighter-weight vehicle structures and better powertrains; energy-efficient mobility technologies and systems (including automated and connected vehicles as well innovations in connected infrastructure for significant systems-level energy efficiency improvement); innovative powertrains to reduce greenhouse gas (GHG) and criteria emissions from hard to decarbonize off-road, maritime, rail, and aviation sectors; and technology integration that helps demonstrate and deploy new technology at the community level. In coordination with the other offices across the Office of Energy Efficiency and Renewable Energy (EERE) and the U.S. Department of Energy (DOE), VTO advances technologies that assure affordable, reliable mobility solutions for people and goods across all economic and social groups; enable and support competitiveness for industry and the economy/workforce; and address local air quality and use of water, land, and domestic resources. The VTO Analysis (VAN) subprogram provides critical information and analyses to prioritize and inform VTO research portfolio planning through technology-, economic-, and interdisciplinary-based analysis, including target-setting and program benefits estimation. VAN projects support analytical capabilities and tools unique to DOE's national laboratories. For data activities, trusted and public data are critical to VTO's efforts and are an integral part of transportation and vehicle modeling and simulation. For modeling activities, the subprogram supports the creation, maintenance, and utilization of vehicle and system models to explore energy impacts of new technologies relevant to the VTO portfolio. Finally, for analysis activities, integrated and applied analyses bring together useful findings and analysis of the energy impacts of transportation systems through the integration of multiple models including vehicle simulation and energy accounting of the entire transportation system. The result creates holistic views of the transportation system, including the opportunities and benefits that advanced vehicle technologies create by strengthening national security, increasing reliability, and reducing costs for consumers and businesses. Overall, VAN activities explore energy-specific advancements in vehicles and transportation systems to inform VTO early-stage research and offer analytical direction for potential and future research investments.

Project Feedback

In this merit review activity, each reviewer was asked to respond to a series of questions, involving multiple-choice responses, expository responses where text comments were requested, and numeric score responses (on a scale of 1.0 to 4.0). In the pages that follow, the reviewer responses to each question for each project will be summarized: the multiple choice and numeric score questions will be presented in graph form for each project, and the expository text responses will be summarized in paragraph form for each question. A table presenting the average numeric score for each question for each project is presented below.

Table 7-1 – Project Feedback

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
VAN033	Analysis of Employment and Other Economic Impacts of Transportation Electrification	Joann Zhou (Argonne National Laboratory)	7-4	3.25	3.75	3.75	3.75	3.63
VAN050	Holistic Modeling of Future Transportation Energy Use and Emissions	Matteo Muratori (National Renewable Energy Laboratory)	7-7	3.75	3.75	3.63	3.75	3.73
VAN051	Regional Optimization of Application and Infrastructure Architecture in Heavy Duty Vehicle Electrification	Vivek Sujan (Oak Ridge National Laboratory)	7-11	3.25	3.50	3.25	3.38	3.39
VAN052	Enhancing the EVI-X National Framework to Address Emerging Questions on Charging Infrastructure Deployment	Eric Wood (National Renewable Energy Laboratory)	7-14	3.50	3.50	3.25	3.25	3.44
VAN053	Medium- and Heavy-Duty Electric Vehicle Load, Operations, and Deployment (HEVI-LOAD) Augmentation for National-Scale Infrastructure Assessment	Bin Wang (Lawrence Berkeley National Laboratory)	7-16	3.50	3.75	2.75	3.50	3.53
VAN054	Managing Increased Electric Vehicle Shares on Decarbonized Bulk Power Systems	Brennan Borlaug (National Renewable Energy Laboratory)	7-18	3.63	3.63	3.63	3.75	3.64

Presentation ID	Presentation Title	Principal Investigator (Organization)	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
VAN055	Assessing Opportunities for Travel Demand Management in the Context of Decarbonization and Equity	Chris Hoehne (National Renewable Energy Laboratory)	7-22	3.33	3.67	3.00	3.50	3.48
VAN056	Agent Based, Bottom Up Medium and Heavy duty Electric Vehicle Economics, Operation, Charging, and Adoption	Thomas Bradley (Colorado State University)	7-25	3.17	3.50	3.33	3.00	3.33
VAN057	Scalable Truck Charging Demand Simulation for Cost-Optimized Infrastructure Planning	Ann Xu (ElectroTempo)	7-28	3.17	3.17	2.67	3.33	3.13
VAN058	ACT States Trucking Analysis	Lynn Daniels (Rocky Mountain Institute)	7-31	3.63	3.63	3.38	3.63	3.59
Overall Average				**3.42**	**3.59**	**3.26**	**3.48**	**3.49**

Presentation Number: VAN033
Presentation Title: Analysis of Employment and Other Economic Impacts of Transportation Electrification
Principal Investigator: Joann Zhou (Argonne National Laboratory)

Presenter

Joann Zhou, Argonne National Laboratory

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

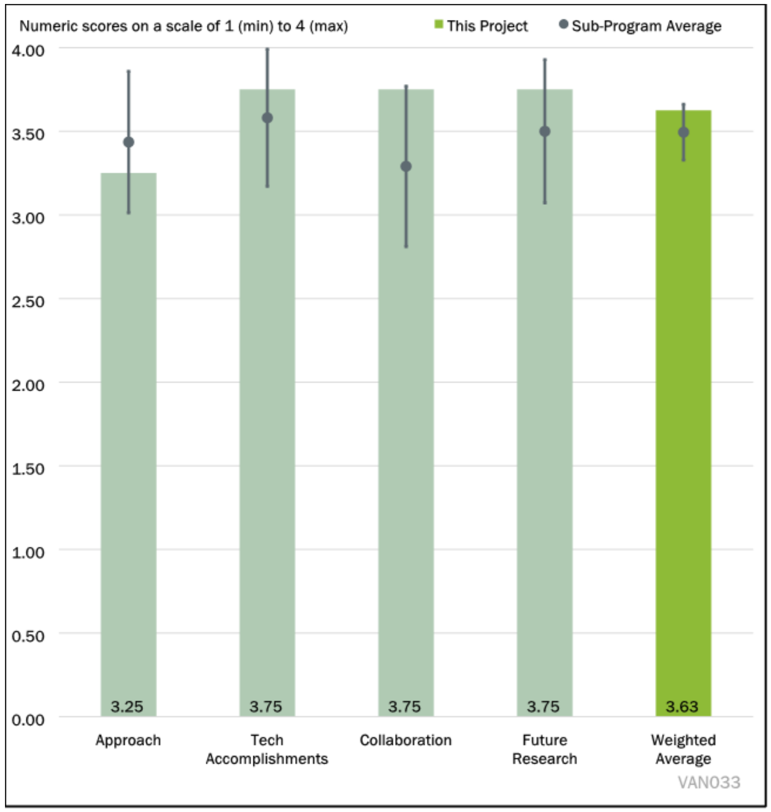

Figure 7-1 - Presentation Number: VAN033 Presentation Title: Analysis of Employment and Other Economic Impacts of Transportation Electrification Principal Investigator: Joann Zhou (Argonne National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer felt the project is well designed. After having been involved in several similar studies, this reviewer saw it as critical to having an industry insider like the Center for Automotive Research (CAR) as a partner to get the best up-to-date information on suppliers, emphasizing, “Well done.” Economic impact studies have well-known challenges because of the many assumptions needed. The reviewer believed that the research team is doing the best they can with this limited tool. One of the most helpful pieces of this research (to the reviewer as a researcher in the field) is the methodology, not necessarily the results (e.g., which North American Industry Classification System [NAICS] codes are used, how certain values are being aggregated or disaggregated, what assumptions regarding time horizon are being used, etc.). The reviewer felt it is important for DOE to stress that this study only deals with the vehicle-side and not with the fuel side impacts. The reviewer stated that there is an open question about which of the two (vehicles or fuels) will have the larger economic impact in decarbonization.

Reviewer 2:

The key technical barriers appeared to the reviewer to be: (1) determining how to understand economic impacts of on-road electric vehicles (EVs), in this case, impacts on employment; and (2) determining how to understand how employment will be impacted by EV adoption (shift in auto industry occupations/skills). The approach to this stage of the project (database development only)—collecting and synthesizing data (literature review and interviews) on current automotive sector employment (magnitude, type, geography), analyzing/summarizing trends, and delivering a database explaining employment by industry corresponding to different stages of the EV lifecycle—is logically reasonable (collect–analyze–summarize) and is a good starting point from which to address the key technical barriers. It would have been helpful to include a concise summary of the full project approach—this presentation does not provide one. It is not clear whether the team intends to compare employment in a hypothetical EV future to a business-as-usual internal combustion engine (ICE) case, or just to estimate "EV jobs created" (what is shown in the Accomplishments Slide 10). Additionally, while scenario modeling is mentioned, it is not clear whether the team intends to address key uncertainties around the trade balance (domestic share of critical minerals mining/processing, battery component manufacturing) and manufacturing improvements. Both of these—a net employment impact along with addressing key uncertainties—are needed to fully address the barriers.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

Based on the presentation, it seemed to the reviewer like the technical accomplishments are: (1) data collection (literature review and interviews) has started; and (2) the preliminary assessment of jobs required to meet different levels of future EV demand in the U.S. has been completed. The reviewer notes an assumption that the team intends to review more literature finding the current findings to be very limited. The reviewer stated that there has been a large amount of research in this space already (think tanks, academia). The reviewer pointed out that the final accomplishments slide does not appear to account for any impacts of scale—projecting the jobs required for 6.3 times more EV production to be simply 6.3 times greater. And the reviewer believed that it does not account for any job losses due to lowered ICE production (unless the assumption is that ICE production will increase and those vehicles will be exported to countries where ICEs will continue to dominate, like Africa, Central/South America, and others). It should also include context regarding supply chain uncertainties - i.e., how much of the supply chain (particularly critical mineral mining and extraction, as well as battery production) will be domestic? Those clarifications should be clearly stated since the presentation uses a headline of "50% EV sales share in 2030 will create 600,000 jobs."

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

There appeared to be collaboration planned, notably with CAR, but nothing specific as of yet.

Reviewer 2:

The research team has an ideal set of collaborators—both original equipment manufacturers and CAR.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer found that the work has a clear path on future research and suggests that the research team address the question about whether economic impacts will differ between light-duty (LD) vehicles versus medium-duty (MD)/heavy-duty (HD) vehicles. The reviewer recognized that decarbonization of MD/HD vehicles is at a different market maturity level than LD vehicles but believes that it would be helpful to understand this difference from a policy-making perspective.

Reviewer 2:

This reviewer believed that the proposed future research supports the overarching goals set earlier in the presentation and progresses logically along the project pathway. The presentation lacked any milestones or timelines; so, determining the project team's progress was difficult for the reviewer. The future research was also defined very generically; so, it might be difficult to say whether it is actually "done" or not.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This project is very relevant to high-level decision makers, such as politicians, regulators, and policymakers. The primary challenge in economic impact studies is clearly conveying the results.

Reviewer 2:

This supports the data component of the VAN subprogram's objectives. Macro impacts are not clearly called out in the Analysis section of the 2020 VTO Annual Merit Review, but they are clearly important to consider when thinking about EV adoption in the U.S.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer suggests that, at minimum, the project team coordinate with other entities that do a lot of work on economic impacts of decarbonization to trade methodologies.

Reviewer 2:

The reviewer points out that there is a lot of work to be done, but the team has another two years to do it, so the reviewer thinks that it is possible given the amount of time. The reviewer professes to not have a good gauge on the macro expertise of the project team—this project requires a lot more than just transportation expertise—but assumes that Argonne National Laboratory has that covered.

Presentation Number: VAN050
Presentation Title: Holistic Modeling of Future Transportation Energy Use and Emissions
Principal Investigator: Matteo Muratori (National Renewable Energy Laboratory)

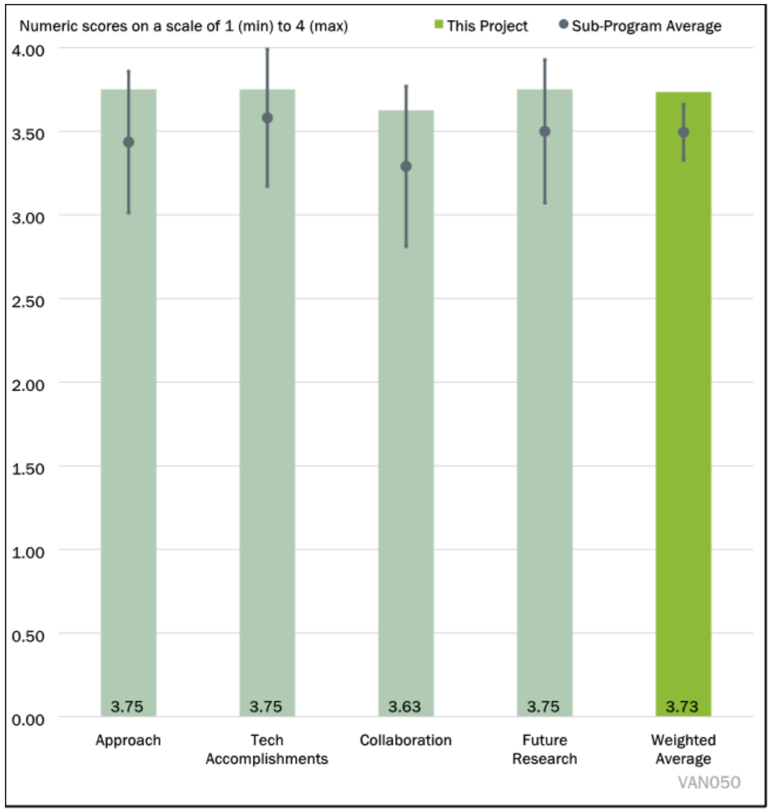

Figure 7-2 - Presentation Number: VAN050 Presentation Title: Holistic Modeling of Future Transportation Energy Use and Emissions Principal Investigator: Matteo Muratori (National Renewable Energy Laboratory)

Presenter

Paige Judan, National Renewable Energy Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer believed that the Transportation Energy and Mobility Pathway Options™ (TEMPO) model fills a critical gap transportation energy modeling. Overall, the project approach is sound and scenario results will likely make important contributions in this area. The stated goals of this project are ambitious, but there seemed to be a good balance in the proposed model enhancements, covering the more specific objectives of improving the zero-emission vehicle (ZEV) adoption scenarios/analysis but also broadening model capabilities to include representatives of other modes and responding to requests. Maintaining a balance will be important throughout the project.

Reviewer 2:

This reviewer believed that the key technical barrier is the current lack of sufficient modeling capabilities to comprehensively assess the range of possible mobility futures and their impacts on research and development (R&D) portfolios, and to do so with a quick turnaround to enable agile decision making. The approach successfully addresses the technical barrier (and sub-components of that barrier). The TEMPO model aims to include the major levers that could change mobility in the future—particularly mode switching, vehicle/fuel choice, policy/standards, and R&D/investment. The approach to taking on this [massive] task is logical—model development and enhancement (supplemented by a steering committee), model maintenance/upkeep, and completing specific analyses using the model in its current state (for the VTO and other National Renewable Energy Laboratory [NREL] scenarios).

Reviewer 3:

This reviewer opined that, overall, TEMPO is an impressive tool with wide applicability throughout the United States among decisionmakers. The technical barriers are being addressed. Many of the reviewer's comments on TEMPO can be seen in other presentations.

Reviewer 4:

This reviewer found that the approaches to overcoming barriers were discussed including the Inflation Reduction Act, treatment of non-LD vehicles and dissemination of modeling methodology but it was acknowledged that there are significant challenges. The project is at an early stage so it appears that decisions will need to be made to allocate budget to barriers that can be overcome and acknowledge where TEMPO may have limitations, e.g., impact of bike lanes and micro-mobility). The reviewer suggests that the team consider the risks/rewards of expected emissions reductions for some of these alternatives to keep the project on track. For impacts of legislation and supply side changes, the reviewer suggests that the team identify models or suites of models that it thinks will assist with this. The reviewer believes that model documentation should continue to be updated on a regular cadence.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer noted that this project is in the early stages but appears to be off to a strong start with interesting preliminary results on ZEV adoption. The inclusion of an equity-focused steering committee member is an important step in advancing equity goals for this project. Equity considerations should continue to be a primary focus in this work, according to the reviewer. The tie-in of the "Convenient" and "Efficient" strategies by including modes other than LD EVs is also promising, and their potential impact on EV adoption scenarios should be interesting.

Reviewer 2:

This reviewer listed a number of accomplishments of the project to date: the steering committee was expanded and a meeting was held; priority Fiscal Year 2023 model enhancements were identified; and initial targeted LD vehicle sales share scenarios were implemented. These accomplishments suggest that the project is on schedule (Slide 6, milestones).

Reviewer 3:

This reviewer believed that a version of "TEMPO-light" would be very useful to practitioners who do not have access to other trusted, national decarbonization models.

Reviewer 4:

According to this reviewer, the project appears to have received valuable feedback from the expanded steering committee. Results for initial implementation of LD vehicle sales shares are in line with what would be expected, e.g., preference for smaller vehicles would lead to less electricity demand. While difficult to present on a slide, it would be helpful to learn more about any potential observations from the range of sensitivities that were run. The reviewer understood that 50% adoption by 2030 is a goal of the current Administration but believes that it is extremely aggressive.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

This reviewer pointed out that collaboration appears to drive a lot of the major decision making on TEMPO, in particular the steering committee. The reviewer stated that it is remarkable that the team managed to get such an expertise-packed group to find time to meet and discuss this project and that it is “great work.”

Reviewer 2:

This reviewer found it very helpful to see the list of partners and has confidence they will provide strong guidance on the direction of this tool.

Reviewer 3:

The reviewer stated that the steering committee is diverse, and the inclusion of an equity expert can be applauded. In addition, there are obvious tie-ins with other VTO/NREL work and it appears that the team is working in collaboration with these teams. The reviewer felt that continuing to improve documentation and expand collaboration with stakeholders will be important going forward, particularly on the demand-related factors and communication of scenarios.

Reviewer 4:

This reviewer found that NREL is coordinating with a good range of public and private entities and assumes that funding was limited such that bringing on partners for this project outside NREL was not feasible.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer found the work is very relevant to VTO objectives and the transportation sector more broadly. The model will be a valuable tool going forward, especially as much as it can support quick turn-around, policy-relevant analysis. The future milestones seem to be achievable while not being too prescriptive and are good markers for success of the project moving forward. The model documentation and publicly available results in particular are of key importance.

Reviewer 2:

The reviewer said that the proposed future research has a clearly defined purpose—it has been prioritized by a diverse steering committee that represents a range of key stakeholders. It is likely this work will achieve its targets given the proven expertise of the team and their past accomplishments.

Reviewer 3:

This reviewer believed that the project has a clearly definite purpose for work for the foreseeable future but that it is unclear at this early stage if the project will fully achieve its targets.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer stated simply that the project is relevant to VTO in a multitude of ways.

Reviewer 2:

This reviewer described how the work and, in particular, the TEMPO model supports all three VAN objectives. It is noted that the latter two, (1) to build, maintain, and exercise relevant analytical models; and (2) to execute insightful integrated analyses that provide greater understanding of critical transportation energy problems, are both directly supported by this project.

Reviewer 3:

This reviewer anticipates that TEMPO will continue to provide needed capabilities to further VTO analysis and inform R&D prioritization. The utility of the model should increase as additional capabilities are added over time.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer found that the resources are sufficient for this project. The large budget will enable rapid/timely results that can be helpful for policy.

Reviewer 2:

The reviewer said that resources appear to be sufficient given the team's past experience and proven ability to build out the TEMPO framework.

Reviewer 3:

This reviewer believed that additional resources could be useful, but it appears that the project is achieving milestones with the level of funding provided. A cautious approach is likely merited as the policy and technology landscapes have shifted significantly in recent years.

Presentation Number: VAN051
Presentation Title: Regional Optimization of Application And Infrastructure Architecture In Heavy Duty Vehicle Electrification
Principal Investigator: Vivek Sujan (Oak Ridge National Laboratory)

Presenter

Vivek Sujan, Oak Ridge National Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

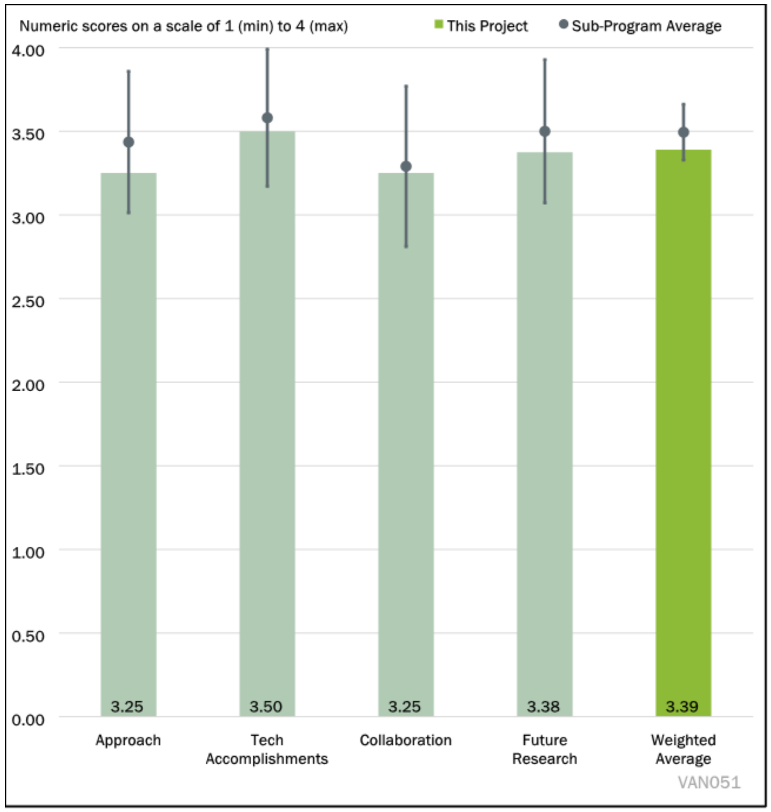

Figure 7-3 - Presentation Number: VAN051 Presentation Title: Regional Optimization of Application And Infrastructure Architecture In Heavy Duty Vehicle Electrification Principal Investigator: Vivek Sujan (Oak Ridge National Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer held that, overall, this project is well designed and utilizes a novel approach to integrating vehicle and infrastructure data. The approach of first focusing on developing a solid framework makes a lot of sense. The reviewer would have liked to hear more about the future scenario visioning and how larger transformation in the sector, such as recent policy and investments, may impact the results.

Reviewer 2:

This reviewer said that the project appears to be well structured to address the technical barriers.

Reviewer 3:

This reviewer found that the energy demand as a function of weather is a good advancement and addition to the approach. The reviewer was dissatisfied with the answer to a question posed on multi-day charging, which is usually key to understanding charging needs and the sizing of batteries across vehicle types.

Reviewer 4:

This reviewer believed that this project will face numerous data barriers as it progresses. It is not entirely clear how successful the team will be in overcoming proprietary data challenges and how this project can be successfully translated to the national level (e.g., whether suggested data sets provide the necessary level of detail), and whether aspects of the Port of Savannah that lend itself to the project, will be available for other ports.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer believed that the project is off to a great start and has met its goals for Fiscal Year 2023 ahead of schedule. The initial progress is promising.

Reviewer 2:

This reviewer noted that the project is on schedule and that the team is well positioned to complete the project as planned.

Reviewer 3:

The reviewer noted that the technical progress at this stage includes a lot of data gathering. This progress appears appropriate at this stage.

Reviewer 4:

This reviewer found that that the team has made good progress on the initial weather data collection and port HD truck freight mobility.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

This reviewer pointed out that the project team has partnered with academia and is also working with industry groups and with other national laboratories. The reviewer was surprised not to hear about collaboration with the actual ports. The reviewer noticed the mention of a partner study related to community impacts but would have liked to hear more about this and how it will be integrated into the project.

Reviewer 2:

The reviewer found that the project has good collaborations with the National Renewable Energy Laboratory, Lawrence Berkeley National Laboratory, and Idaho National Laboratory, but the short presentation did not make clear what the specific value of contributions are. There are also specific partnerships with Ohio State University and Stanford Linear Accelerator Center, plus advisory input from others. This reviewer wonders if such detailed cell level battery modeling is needed due to the uncertain results when predicting future scenarios because, while temperature matters, weather is very variable.

Reviewer 3:

This reviewer found that the project coordinates across universities, national laboratories and others and wonders what the interaction and distinctions are with HEVI-LOAD which also sites infrastructure and deals with similar topics. How are they distinct?

Reviewer 4:

This reviewer believed that team diversity appears to be a strength for this project, with members from multiple organizations as well as additional collaborators and consultants.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer believed that the work to date has set up a strong methodology for the project going forward. As noted by the team, scaling up the data integration nationally could be challenging. The reviewer would have liked some more detail on feasibility and how to overcome barriers.

Reviewer 2:

This reviewer found that future work appears to be well planned to achieve the project goals and targets.

Reviewer 3:

This reviewer said that research targets will move from scenario analysis to optimization between the vehicle and charging. Vehicle-grid integration would be a great addition as it may be important in the future.

Reviewer 4:

This reviewer pointed out that the project is still in year one. It was not entirely clear if the project will fully meet future goals given complexity of modeling and expansion to additional ports.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer thought that the project is relevant and fills an important gap. The data integration itself will be valuable across several goals.

Reviewer 2:

This reviewer noted that the highly integrated system modeling of HD trucking at ports supports many of VTO programs and objectives.

Reviewer 3:

This reviewer agreed that heavy duty charging needs a significant amount of analysis and believes that this project addresses a few key aspects well, including weather.

Reviewer 4:

This reviewer believed that the project should provide useful insights for the VTO Analysis program as well as inform other VTO programs such as Batteries, Electrification, Energy Efficient Mobility Systems (EEMS) and Decarbonization of Off-Road, Rail, Marine, and Aviation (DORMA).

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer found that the resources for this project seem sufficient.

Reviewer 2:

The reviewer believed that the resources seem sufficient, and project is on-time and on-budget.

Reviewer 3:

The reviewer said that $1.5 million over 3 years seems about right.

Reviewer 4:

This reviewer felt that the staging for this project seems appropriate. In light of the challenges throughout the life of the project, thoughtful consideration at go/no-go periods should help to ensure that the project remains on track and within budget.

Presentation Number: VAN052
Presentation Title: Enhancing The EVI-X National Framework To Address Emerging Questions On Charging Infrastructure Deployment
Principal Investigator: Eric Wood (National Renewable Energy Laboratory)

Presenter

Eric Wood, National Renewable Energy Laboratory

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

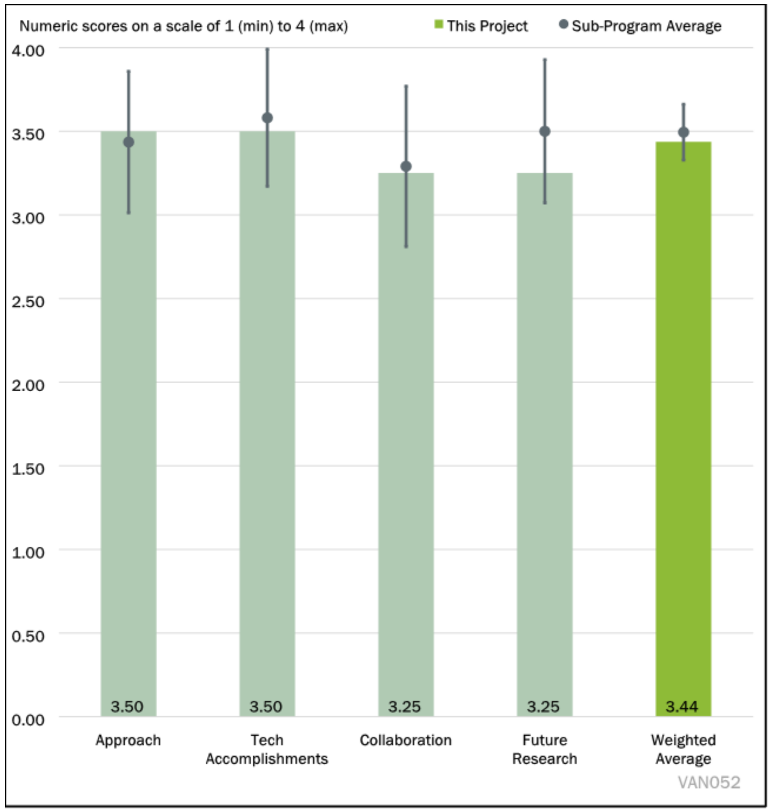

Figure 7-4 - Presentation Number: VAN052 Presentation Title: Enhancing The EVI-X National Framework To Address Emerging Questions On Charging Infrastructure Deployment Principal Investigator: Eric Wood (National Renewable Energy Laboratory)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer opined that the research team is doing an incredible job addressing the technical barriers and continues to be very impressed with the quality of the research coming from this group at NREL.

Reviewer 2:

This reviewer stated only that the project is still in early stages.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer stated that it appears that the project is on track for the two milestones that were presented. It was not clear what milestones there are for the project beyond Fiscal Year 2023.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer found that, while the team is collaborating with a wide range of stakeholders, it could be useful to consider engaging with a few additional states beyond California and New York that have less ambitious climate goals and/or incentives for electric vehicle purchasing.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The reviewer questioned, based on the relatively low overall budget, whether the work identified on the presentation's Slide 17 – "Proposed Future Work" is in scope for this project.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer pointed out that the findings should be particularly relevant for the mission of the Joint Office of Energy and Transportation.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that it is not entirely clear from the presentation whether what is shown on Slide 17 as "Proposed Future Work" is in scope for this project, which makes it difficult to assess the appropriateness of the overall budget.

Presentation Number: VAN053
Presentation Title: Medium- and Heavy-Duty Electric Vehicle Load, Operations, And Deployment (HEVI-LOAD) Augmentation For National-Scale Infrastructure
Principal Investigator: Bin Wang (Lawrence Berkeley National Laboratory)

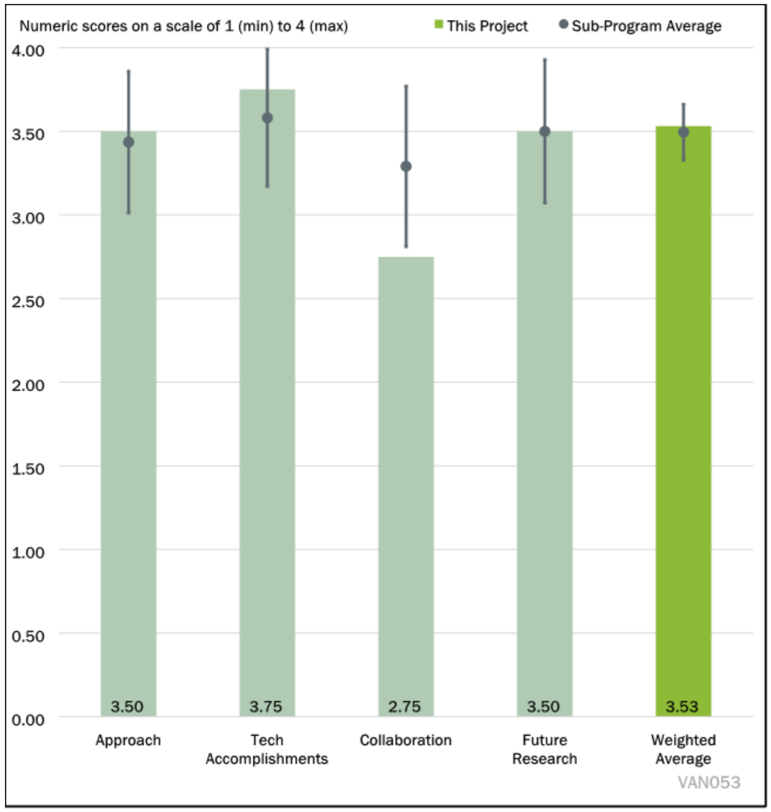

Figure 7-5 - Presentation Number: VAN053 Presentation Title: Medium- and Heavy-Duty Electric Vehicle Load, Operations, And Deployment (HEVI-LOAD) Augmentation For National-Scale Infrastructure Principal Investigator: Bin Wang (Lawrence Berkeley National Laboratory)

Presenter

Bin Wang, Lawrence Berkeley National Laboratory

Reviewer Sample Size

A total of two reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 50% of reviewers felt that the resources were sufficient, 50% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

The reviewer found that the approach for this work is sound and is built on a good foundation to be successful. The bottom-up approach will be especially informative for identifying candidate locations for charger deployment, considering areas with sufficient grid capability as well as identifying gaps.

Reviewer 2:

This reviewer believed that the project could be improved with better data calibration from fleet sources and better validation of consumer behavior.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer stated that the project has shown good progress so far with some promising preliminary results.

Reviewer 2:

This reviewer said that progress is good overall.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

This reviewer was pleased to see NREL as a partner because collaboration and coordination with related infrastructure modeling (e.g., Electric Vehicle Infrastructure Projection Tool [EVI-Pro]) will be important. The main critique on collaboration is that the outreach and feedback to stakeholder should happen before and concurrently with web-tool development to make sure the investment is meeting their needs.

Reviewer 2:

This reviewer believed that more feedback from fleets on charging behavior examples would be beneficial and that more comparison with results from other studies would improve the explanatory power of the modeling.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer found the future research to be well-planned and that the targets are achievable. But the reviewer also believes that, as far as developing a useful stakeholder tool is a goal of the project, it would help to put more focus on how to do this effectively.

Reviewer 2:

This reviewer believed that the team is working through the identified shortcomings.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer believed the project is highly relevant to VTO Analysis objectives.

Reviewer 2:

This reviewer stated that MD and HD charging is of large importance to electrification and more modeling is needed to begin to understand the issues and tradeoffs.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer believed that the resources for this project are sufficient for the stated targets, but to make this tool even better, VTO might consider more investment.

Reviewer 2:

This reviewer said that the project could use more resources given the scope of the issue. More data is needed and will require budget resources and more outreach to companies and institutions would also be desirable.

Presentation Number: VAN054
Presentation Title: Managing Increased Electric Vehicle Shares on Decarbonized Bulk Power Systems
Principal Investigator: Brennan Borlaug (National Renewable Energy Laboratory)

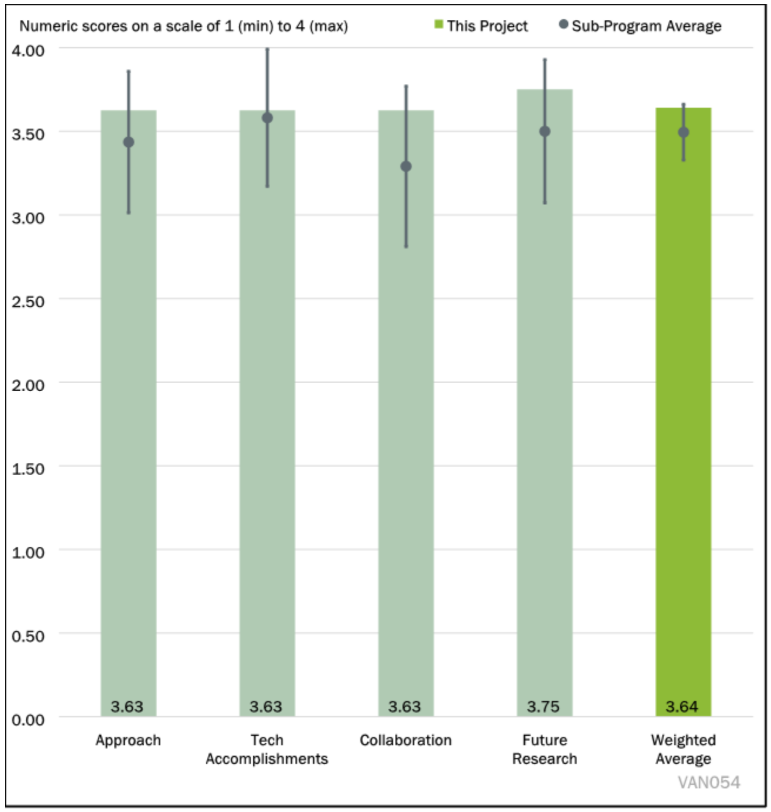

Figure 7-6 - Presentation Number: VAN054 Presentation Title: Managing Increased Electric Vehicle Shares on Decarbonized Bulk Power Systems Principal Investigator: Brennan Borlaug (National Renewable Energy Laboratory)

Presenter

Brennan Borlaug, National Renewable Energy Laboratory

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

According to this reviewer, the key barriers included that: (1) electric vehicle (EV) charging demand is uncertain; (2) the benefits of managed charging are unclear; and 3) the bulk power system development in response to increased EV adoption is under-researched. The approach of this project makes sense—using estimates of electricity demand from a high-EV adoption scenario projection and then seeing the power system would meet that demand using NREL Demand Side Grid model (dsgrid-flex) and Regional Energy Deployment System model (ReEDS), i.e., model both supply of and demand for electricity. In order to accurately assess grid capacity and dispatch capability, the team is doing this at a very granular level (hourly, county/region). And to assess the impact of managed charging, the team is running two different load profiles: managed and unmanaged. There did not appear to the reviewer to be any pricing mechanism. The reviewer pointed out that TEMPO uses an electricity price for its projection of demand. It then sends that demand to the supply-side models. The reviewer asked if those models simply show that demand being met at the electricity price assumed in TEMPO. The reviewer did not find anything saying that the supply and demand models are linked, or are iterating, to balance the market using price. While this project may be aiming solely to assess grid impacts of a given level of demand, the reviewer believed that demand cannot be determined independently of a fuel price. If meeting TEMPO's EV demand requires increased electricity prices, that should be fed back through TEMPO so demand can respond.

Reviewer 2:

This reviewer found that the project has an impressive and ambitious technical scope and has no issues with the framework presented in Slides 4, 5, 17, etc. One aspect of this the reviewer believed is lacking in the slides and presentation is upgrades to the distribution system. The reviewer questioned whether ReEDS models those upgrades. Most MD charging requires some upgrades both to-the-meter and behind-the-meter. In an evaluation of 14 utility programs in California, these costs were found to be \$50,000–\$450,000 for MD/HD sites (not including the cost of the electric vehicle supply equipment [EVSE] itself). See Figure 56 as an example of these costs of last year's evaluation for a snapshot of these costs https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/sb-350-te/sb-350-standard-review-programs-annual-transportation-electrification-evaluation-2021.pdf. The reviewer also wondered how the team is modeling the human behavioral aspect of managed charging. The load that vehicle operators are willing to shift may be well short of what can technically be shifted. In the referenced evaluation of 14 utility programs in California, very few fleets were shown to manage charging even when they had a strong financial incentive to do so (via time of use rates) and even when they had time each night in off-peak hours when their vehicles were plugged in but no longer charging. Just as surprising, many of the MD/HD vehicle operators simply needed to push a button on their EVSE to enable the charge management. The reviewer concluded that there is a major difference between economically rational behavior and actual observed behavior with charge management. The reviewer suspected that, as MD/HD electrification scales up, so too will the knowledge of managed charging, making the point possibly moot when modeling to 2050.

Reviewer 3:

The reviewer said that the project leverages expertise and existing modeling tools at NREL in transportation demand, EV energy demand, and bulk grid modeling to estimate the impact of LD and MD/HD vehicle electrification on grid energy demand and capacity expansion. The approach makes use of scenario analysis to estimate how different potential futures may result in different electricity demands. The team has experience integrating different assumptions into these models and can make use of NREL computing resources to integrate these large models.

Reviewer 4:

This reviewer said that the project appears to be well structured to address the technical barriers.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer found that the accomplishments are significant given the small amount of project time that has progressed. These include assembling the advisory committee, meeting with that committee to narrow down a list of research questions, developing scenario factors to answer those questions, enhancing the LD vehicle model to more accurately analyze differing charging station locations, and a big lift on the MD/HD vehicle data analysis side (Freight Analysis Framework, Vehicle Inventory and Use Survey, registrations, NREL Fleet DNA). This aligns with what the reviewer believes to be the project plan on Slide 13—finishing the Q1 milestone and building toward the Q3.

Reviewer 2:

The reviewer noted that the project is still in early stages, so deliverables to date have focused on assembling a technical advisory committee (TAC) and defining how scenarios will be selected. The project seems to be on track.

Reviewer 3:

This reviewer considered the project to be on schedule and making progress but suggests that it is difficult to evaluate the progress this early in the project. More results in the coming year will probably show more accomplishments.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

This reviewer pointed to the large diverse group of stakeholders in the TAC. It seems like the team is engaging them at most of the important decision points and before most of the publications.

Reviewer 2:

The project team leverages diverse teams at NREL and a TAC with original equipment manufacturers, utilities, etc. The project proposes to hold meetings with the TAC several times per year to solicit feedback.

Reviewer 3:

There is planned coordination with several national laboratories, but it is not clear what the contributions are so far. Coordination with VAN051 should be demonstrated. The TAC has been established and appears to provide very good input and guidance.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer opined that the proposed future work progresses logically toward addressing the overall technical barriers. Given the current modeling capability, and the proven expertise of the project team, the reviewer expected the future work to achieve the targets laid out.

Reviewer 2:

According to this reviewer, the project is still in early stages, the proposed work includes key tasks with respect to developing models of transportation demand (and associated energy demand) for each county on an hourly basis. The team has identified parameters to guide its scenario selection and will use these scenarios to handle some of the uncertainty associated with the analysis. The reviewer would encourage the team to include “stress test” cases, either based on typical energy demand but higher/lower values of adoption of different technologies. Because transportation data are limited to “typical” values, it may be helpful to model even historical peak travel demand (and energy) data with other electrification energy trends to contextualize how vehicle electrification compares to other electrification trends for driving changes on the grid.

Reviewer 3:

This reviewer said only that future work appears to be well planned to achieve the project goals and targets.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer stressed that the project is specifically relevant to all three of the VAN Annual Progress Report objectives, but specifically to, (1) build, maintain, and exercise relevant analytical models and (2) execute insightful integrated analyses that provide greater understanding of critical transportation energy problems. This expands beyond vehicle-level analysis as well, into grid-side impacts, which is a significant consideration in any potential future with high EV adoption.

Reviewer 2:

The reviewer stated that the project is aligned with VAN subprogram objectives to provide analysis of the impact of medium/heavy duty vehicle electrification on the energy system more broadly.

Reviewer 3:

The reviewer says that the project goals should serve many of the VTO objectives, including for HD trucks interacting with the electric grid.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer found that the project resources appear to be sufficient and voices no concerns.

Reviewer 2:

The reviewer determined that the resources for this project are sufficient for the size of the team and scope of work.

Reviewer 3:

This reviewer said that resources appear sufficient, and that the project is on-time and on-budget.

Presentation Number: VAN055
Presentation Title: Assessing Opportunities for Travel Demand Management in the Context of Decarbonization and Equity
Principal Investigator: Chris Hoehne (National Renewable Energy Laboratory)

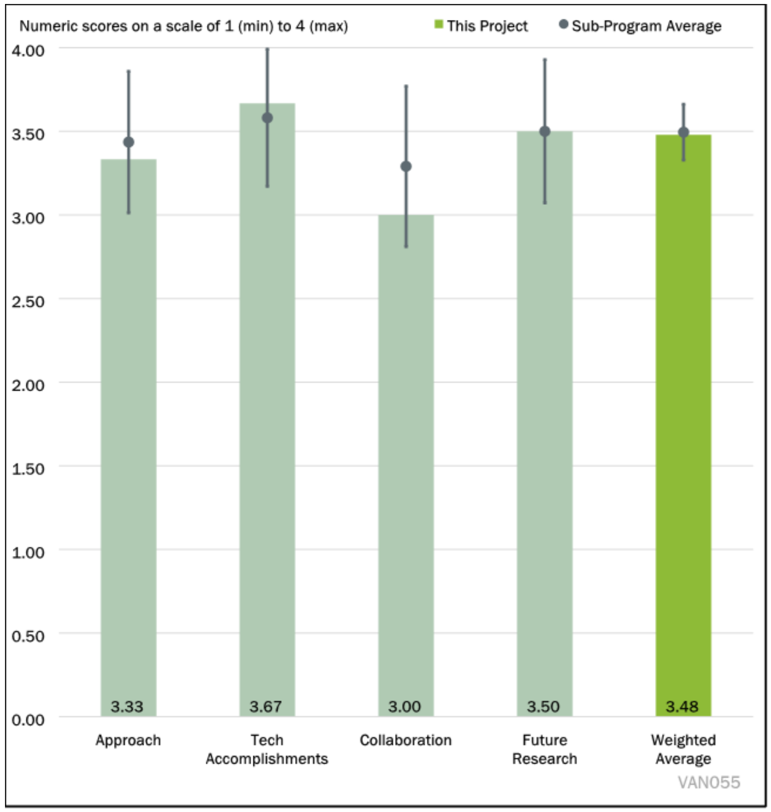

Figure 7-7 - Presentation Number: VAN055 Presentation Title: Assessing Opportunities for Travel Demand Management in the Context of Decarbonization and Equity Principal Investigator: Chris Hoehne (National Renewable Energy Laboratory)

Presenter

Chris Hoehne, National Renewable Energy Laboratory

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer applauded the DOE for diving into this topic because it regularly arises in discussions about transportation decarbonization—in particular, when discussing the extent government should prioritize/incentivize travel demand management (TDM) versus electrification. The reviewer thought that the need for interagency coordination (in particular with state departments of transportation, Metropolitan Planning Organizations, and the Federal Highway Administration (FHWA) is critical for the success and acceptance of this study, given these other agencies' domain expertise. The reviewer has overseen two studies on 2050/net zero modeling that include TDM strategies in the states of Massachusetts and New York. The modeling used the Energy and Emissions Reduction Policy Analysis Tool (EERPAT) and VisionEval Tools, respectively. Based on this experience, the reviewer's main caution for the research team is that TDM impacts different regions in a heterogenous way (e.g., TDM strategies used in dense, urban regions will have a very different impact than the same strategies in rural regions; alternatively, TDM impacts regions with strong public transit differently than regions without public transit, etc.). This was seen in particular in the State of New York modeling of New York City (NYC) versus more rural regions in New York—the results in NYC simply did not make sense using the VisionEval models. The take-away for that team of modelers was that different model parameters are needed for different regions and even applying different urban/rural parameters is insufficient for a place like NYC. Additionally, it was learned that any type of model validation becomes very arduous when including multiple regions. If TEMPO is to be used at the sub-national level, the DOE team should be especially careful.

Reviewer 2:

This project appears to be well structured to address the technical barriers. There will be a lot of uncertainty in trying to make predictions at the national scale.

Reviewer 3:

This reviewer found that the timeline for this project seems reasonable. The reviewer's main concern on the approach is that it is not clear what methodology is to be used for assessing equity impacts.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

The reviewer stated that the project appears to be on track and has achieved key objectives in the early stages.

Reviewer 2:

The reviewer felt that the project milestones look fine and expects the bulk of the work to be in validating model results in Fiscal Year 2024.

Reviewer 3:

This reviewer noted that only 15% of the project has been completed at this time. This project appears to be on schedule and making progress, but it is difficult to evaluate the progress this early in the project. More results in the coming year will probably show more accomplishments.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

Collaboration seems to be mainly through the TEMPO steering committee. It may be useful to connect more broadly with transportation planning community, including TDM practitioners. This could be in the works with the connection to Stanford and industry connections. The reviewer felt this could really strengthen this project.

Reviewer 2:

Slide 3 mentions convening an interagency group to develop tools/data around TDM but it is not clear if the bullets on Slide 13 are that group or just the TEMPO steering committee.

Reviewer 3:

This project overlaps with or make use of other VAN projects at NREL. The TEMPO Steering Committee seems like a very good resource for this project for input and collaboration.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

The efforts to integrate TDM scenarios into TEMPO and the specific focus on equity impacts are valuable. Glad to see this work proposed. However, given the challenges with the lack of good national data and studies, coming up with robust inputs that meaningfully capture TDM strategies in TEMPO could be challenging. The reviewer wondered if expanding on available data by including impacts of actions that were not expressly taken for the purpose of TDM would be possible. For example, maybe the Department of Transportation has data on congestion mitigation approaches such as the Congestion Mitigation and Air Quality Improvement program, managed lanes, congestion pricing, etc., that may not appear in the academic literature. COVID travel was mentioned as a barrier, but maybe there is data from "natural experiments" that could be leveraged here.

Reviewer 2:

This reviewer stated that future work appears to be well planned to achieve the project goals and targets.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer believed that this work is very relevant to VTO/VAN objectives, and broadly the goals laid out in the U.S. National Blueprint for Transportation Decarbonization. There is not enough work in this area.

Reviewer 2:

This reviewer found that the project supports the overall VTO subprogram objectives. The reviewer understands the need for including TDM in TEMPO and believes that the team is aware of the challenges of modeling TDM at the national level. The reviewer recommended that the team coordinate with VisionEval developers at FHWA or Resource Systems Group and suggested the following resource: http://pooledfund.org/Details/Study/621.

Reviewer 3:

This reviewer held that the integrated system modeling of national travel demand supports many of VTO objectives.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer found that the resources seem reasonable.

Reviewer 2:

This reviewer said that the resources appear sufficient, and the project is on-time and on-budget.

Reviewer 3:

This reviewer suggested that, if it has not already, the research team should familiarize itself with the VisionEval strategic planning tools, funded in part by FHWA.

Presentation Number: VAN056
Presentation Title: Agent Based, Bottom Up Medium and Heavy Duty Electric Vehicle Economics, Operation, Charging, and Adoption
Principal Investigator: Thomas Bradley (Colorado State University)

Presenter

Thomas Bradley, Colorado State University

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

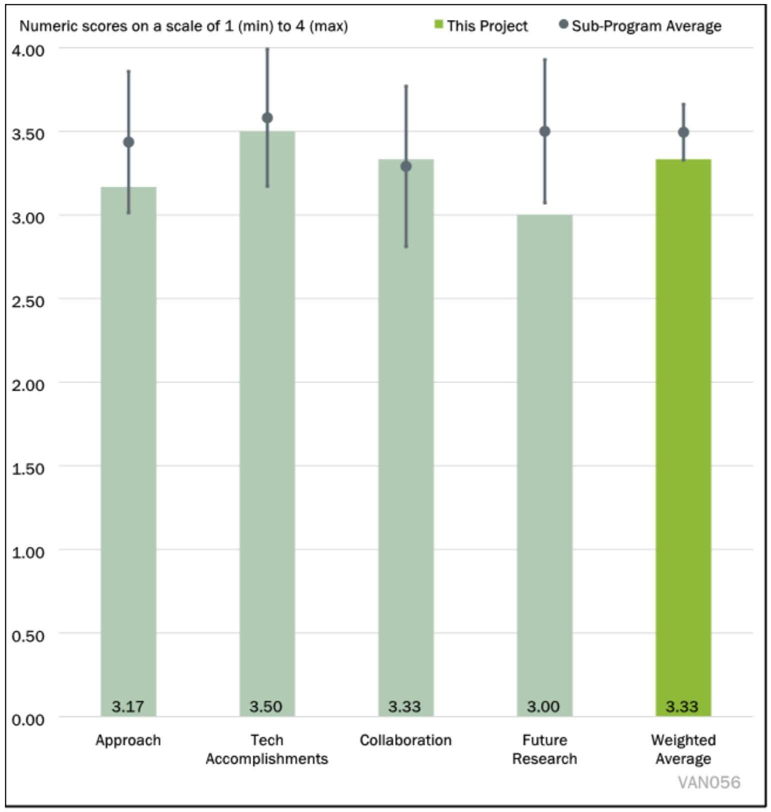

Figure 7-8 - Presentation Number: VAN056 Presentation Title: Agent Based, Bottom Up Medium and Heavy Duty Electric Vehicle Economics, Operation, Charging, and Adoption Principal Investigator: Thomas Bradley (Colorado State University)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer noted that the project uses agent-based modeling to estimate adoption of MD and HD electric vehicles amongst types of fleets. The perception of EVs is driven by perceptions expressed in academic and industry-facing literature. Total costs of ownership included in the analysis are hardware driven. The reviewer found it unclear from the presentation what kind of validation activities have taken place. There were sample vehicle fleets included in the analysis, but it is unclear whether the use of academic and industry literature is truly the best predictor for changing agent behaviors in these fleets. Total cost of ownership also likely varies significantly by fleet application (e.g., downtime and associated labor costs may impact some industries, but not others where vehicle utilization is already low. Some sample statistics were displayed although other analyses show that labor costs/downtime are larger portions of vehicle costs).

Reviewer 2:

This reviewer found that the project appears to be well structured to address the technical barriers.

Reviewer 3:

This reviewer believed that it is still early to assess if this is the right tool, but it is novel, and the reviewer was excited to see how the project progresses. The reviewer would like to see the validation of the approach on real fleets’ decision to electrify or not.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer pointed out that progress to date has focused on developing the agent-based modeling framework along with some initial analysis of the role that different vehicle types/ranges might have on potential adoption. The project appears to be on track.

Reviewer 2:

This reviewer said that the project is on schedule and is well positioned to complete the project as planned and asked whether any of the peer reviews occurred?

Reviewer 3:

This reviewer found that there is a lot of progress on the methodological underpinnings.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer pointed out that the project team includes a university lead organization with industry and nonprofit partners that can provide some insight into vehicle adoption and grid operations. Additional industry partners or interaction with some fleet operators may help to expand the types of fleets that can be examined/modeled and may help to identify other factors that influence vehicle adoption for fleets.

Reviewer 2:

This reviewer believed that the project appears to have good collaborations with the project partners. There is some synergy and overlap with other VAN projects and data, so the reviewer urged that the team be sure to coordinate with them where possible.

Reviewer 3:

This reviewer noted that the team appears to have lots of interaction with others but would like to see concrete examples of how the model has been influenced by others as the project progresses.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer described how the proposed future work will use the agent based and economic models developed to date to examine potential impacts of subsidies (and their long-term impact on the vehicle market) and the normalization of technology in some vehicle classes spilling over into other vehicle classes. The results will also expand to account for more simulated agents at state and entire transportation network levels. There are some technical (computing) challenges to scaling, but as the project expands, it would be helpful to continue to validate whether the agents across states or across entire networks have similar behavior/characteristics as those agents modeled at the regional level.

Reviewer 2:

This reviewer found that future work appears to be well planned to achieve the project goals and targets. The establishment of the quality and reliability of the projections needs to be defined. The reviewer asks whether there is any plan to support the new tools beyond the project?

Reviewer 3:

This reviewer would like to see external validation of some kind in the future research so that it can be determined whether it is capturing anything real otherwise.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

The reviewer found that the project is aligned with the VAN program objectives to analyze how technology, policy, and economic conditions impact the market demand for electrified MD and HD vehicles.

Reviewer 2:

This reviewer said that the project's integrated system modeling of MD and HD trucking EV adoption with charging supports many of the VTO objectives.

Reviewer 3:

This reviewer said that the project is relevant to electrification.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that the resources for this project are sufficient for the size of the team and scope of work.

Reviewer 2:

The reviewer stated that the resources appear sufficient, and the project is on-time and on-budget.

Reviewer 3:

The reviewer stated that it seems like there are sufficient resources.

Presentation Number: VAN057
Presentation Title: Scalable Truck Charging Demand Simulation for Cost-Optimized Infrastructure Planning
Principal Investigator: Ann Xu (ElectroTempo)

Presenter

Ann Xu, ElectroTempo

Reviewer Sample Size

A total of three reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

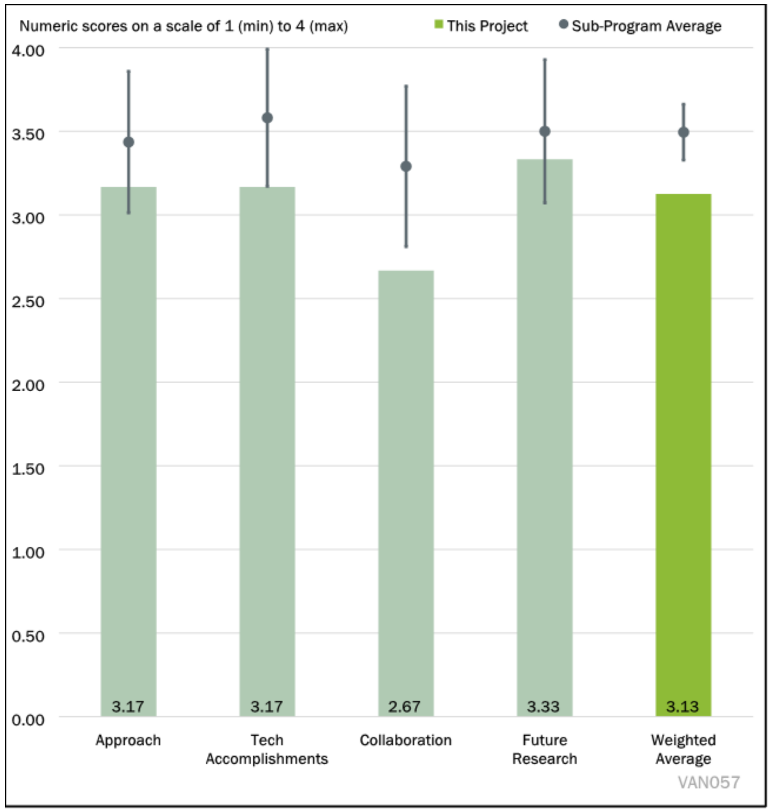

Figure 7-9 - Presentation Number: VAN057 Presentation Title: Scalable Truck Charging Demand Simulation for Cost-Optimized Infrastructure Planning Principal Investigator: Ann Xu (ElectroTempo)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer identified that the key barrier to be that truck data and modeling systems are not granular enough to accurately assess the potential impacts of electric vehicle (EV) adoption on local grids. The reviewer characterized the approach as to develop a high-resolution, detailed simulation model that is fast, affordable, and scalable to estimate infrastructure requirements for a given level of EV demand. and then to apply the framework to two different case studies to validate. This approach addresses the stated technical barrier. According to the reviewer, the project is well-designed, and the timeline appears to be reasonably planned (sufficient progress is being made; milestones and go/no-gos are well-defined).

Reviewer 2:

This reviewer found that the project appears to be well structured to address the technical barriers. The reviewer questions, however, how the fine time and space resolutions the team is attempting to use to model peak loads will provide more meaningful results considering the high uncertainty of many inputs.

Reviewer 3:

This reviewer would like to see more validation on real data and more explicit link to charging behavior such as whether this model could be applied to diesel trucks and fuel demand/ fuel usage. The reviewer questioned what could be learned without an explicit link to outside refueling behavior validation. The reviewer also asked whether the model assumes that truck charging will mirror diesel refueling, suggesting that a lot of charging would be done at depots rather than at public truck stops.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer affirmed that the team successfully generated estimates of truck travel demand and developed a model to site supporting truck depots, followed by estimating energy per truck and then total truck charging demand. The reviewer believed that it would be helpful for the team to expand on how the truck duty cycles (weight class and vocation/tractor) were estimated, since that strongly impacts both the daily miles driven per truck as well as the trucks' fuel economy.

Reviewer 2:

This reviewer noted that the project is on schedule and that the team seems well positioned to complete the project as planned.

Reviewer 3:

This reviewer said simply that the project seems to have potential.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

The reviewer pointed out that the team is working closely with Texas A&M University but did not see anything specific about the other partners. The reviewer believes, nonetheless, that it seems likely that other partners may be able to provide valuable assessment of the model results.

Reviewer 2:

This reviewer found the role of Texas A&M Engineering Experiment Services to be not clear. Because the reviewer believes that there is some overlap with other VAN projects and data, the reviewer advises the team to be sure to coordinate with those projects.

Reviewer 3:

This reviewer noted only that the project includes some project partners.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer agreed that the proposed future research progresses logically, stating that, now that the charging demand has been estimated, the team plans to identify grid impacts based on different levels of EV adoption. Hopefully the team will, in addition to estimating the aggregate cost of required upgrades, estimate the future cost per kWh (or some other pricing mechanism, like a demand charge) that electric trucking fleets would need to pay (including amortization of the new grid equipment).

Reviewer 2:

This reviewer found that the future work appears to identify studies to use the tools developed but with no plan to resolve the challenges identified.

Reviewer 3:

This reviewer believed that that the model needs better representation of depot demand vs. en-route demand.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer points out that the project directly addresses VAN 2020 Annual Progress Report objectives, including: (1) build, maintain, and exercise relevant analytical models; and (2) execute insightful integrated analyses that provide greater understanding of critical transportation energy problems. It does this via building a new simulation model that integrates both transportation demand as well as electricity supply to meet that demand, in order to assess the charging needs and grid impacts of those needs.

Reviewer 2:

This reviewer said that the integrated system modeling of HD EV trucking and electric grid infrastructure supports many of the VTO objectives.

Reviewer 3:

This reviewer said that the project is relevant to electrification.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer found that the resources appear to be sufficient given the team’s expertise and the amount of work allocated to the timeframe.

Reviewer 2:

This reviewer noted that the resources appear sufficient, and the project is on-time and on-budget.

Reviewer 3:

This reviewer said that the team seems to have enough people.

Presentation Number: VAN058
Presentation Title: ACT States Trucking Analysis
Principal Investigator: Lynn Daniels (Rocky Mountain Institute)

Presenter

Emily Porter, Rocky Mountain Institute

Reviewer Sample Size

A total of four reviewers evaluated this project.

Project Relevance and Resources

100% of reviewers felt that the project was relevant to current DOE objectives, 0% of reviewers felt that the project was not relevant, and 0% of reviewers did not indicate an answer. 100% of reviewers felt that the resources were sufficient, 0% of reviewers felt that the resources were insufficient, 0% of reviewers felt that the resources were excessive, and 0% of reviewers did not indicate an answer.

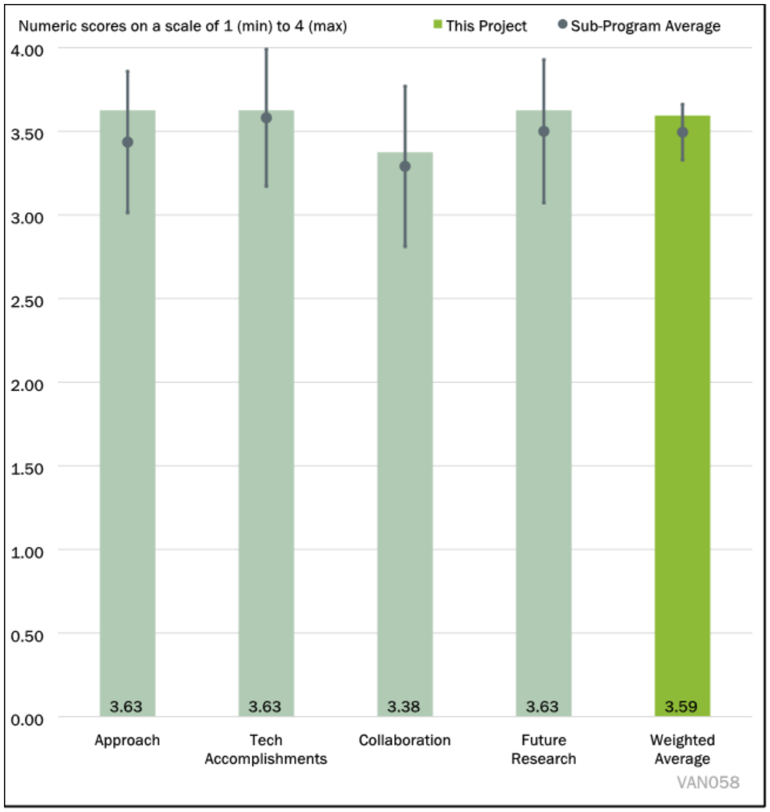

Figure 7-10 - Presentation Number: VAN058 Presentation Title: ACT States Trucking Analysis Principal Investigator: Lynn Daniels (Rocky Mountain Institute)

Question 1: Please comment on the degree to which technical barriers are addressed. Is the project well designed, and is the timeline reasonably planned?

Reviewer 1:

This reviewer believed that the approach used for this study is sound and is a good example of using a new real-world data source for insight on charging profiles. It is also well-balanced in the sense of using a novel methodology and contributing important analytical results, while also centering on stakeholders, which is important for the reach and broader impact of this work. The results are somewhat limited due to the focus on Advanced Clean Truck (ACT) states only, but the general approach has promise to replicate more broadly.

Reviewer 2:

This reviewer considered the key technical barrier to be a lack of information on the charging infrastructure that might be required to support a large fleet of fully-electric trucks in California ACT states. The approach adequately addresses this barrier, by collecting real-world travel data from Geotab loggers, segmenting that data based on whether trucks can or cannot be electrified, and estimating the charging requirements needed to meet the electric truck travel demand. This should provide a reasonable estimate of the charging demands (by county) for a high-electric vehicle truck adoption scenario. According to the reviewer, it would be valuable to include an estimate of how representative these truck data are of the total freight truck population in the United States (Slide 7 says it "covers approximately 10% of MD and HD trucks based in 15 ACT states in 2019"). Another question the reviewer posed is whether this covers a large portion of the freight truck vehicle miles travelled (VMT), noting that 40% of the truck fleet is very different from 40% of the truck VMT.

Reviewer 3:

This reviewer found that the project appears to be well structured to address the technical barriers. The scope only includes ACT states.

Reviewer 4:

The reviewer liked the tie to real data, saying that it leverages what can be observed now to what will be needed to serve in the future and that it includes a good tie to policy.

Question 2: Please comment on the technical progress that has been made compared to the project plan.

Reviewer 1:

This reviewer believed that the project has made excellent progress and is well on its way to completion. The team has demonstrated a successful methodology, has shared results to date, and is close to development of a public facing user interface.

Reviewer 2:

This reviewer said that the technical accomplishments indicate that a significant amount of the project plan has been completed, proportionate to the amount of time/resources that have been spent. The team has already collected logger data, processed that data (including extraction of vehicles that are “electrifiable”), and has started to draw conclusions from it. Additionally, it has been able to estimate hypothetical electricity consumption by county for those electrifiable vehicles.

Reviewer 3:

This reviewer said that the project is on schedule and is well positioned to complete the project as planned.

Reviewer 4:

This reviewer found that the project has provided useful data so far.

Question 3: Please comment on the collaboration within the project team. Are there specific contributions made by industry, national laboratories, or other external entities? Are there areas where more collaboration is needed?

Reviewer 1:

This reviewer applauded the project as having excellent collaboration with partners, believing it to be smart of the team to get feedback from utilities and policy makers for the beta launch.

Reviewer 2:

This reviewer stated that the project team is optimally set up—a data collector (Geotab), assumption validator (North American Council for Freight Efficiency for miles per gallon, travel, stock), and analyst (Rocky Mountain Institute). Solid collaboration is what has enabled the progress so far.

Reviewer 3:

The reviewer believed that this project makes good use of collaborations with other organizations to source information for the modeling. Believing that there is a fair amount of synergy and overlap with other VTO Analysis projects, the reviewer urges the team to coordinate with these projects.

Reviewer 4:

This reviewer felt that the team could coordinate more with other entities and asks whether it has contacted ACT states.

Question 4: Please comment on the proposed future research. Has the project clearly defined a purpose for future work? To what extent will future work likely achieve its targets?

Reviewer 1:

This reviewer pointed out that the project is 75% complete and has work already underway to meet the future research objectives. The team is well positioned to achieve their targets and has a good plan to overcome data barriers.

Reviewer 2:

The reviewer noted that the proposed future research supports the project goals, via refinement of existing results, as well as by developing ways to share findings (dashboards, tools, reports).

Reviewer 3:

This reviewer considered that the future work appears to be well planned to achieve the project goals and targets. The reviewer asked whether there a plan to support the proposed web tool past the project conclusion.

Reviewer 4:

This reviewer stated that the approach so far is good but that there is more work to do.

Question 5: Please comment on the relevance of the project. Does the project support the overall VTO subprogram objectives?

Reviewer 1:

This reviewer confirmed that the project is relevant to the VTO objectives, especially given the importance of better understanding uncertainty in grid impacts.

Reviewer 2:

This reviewer said the project aligns with the VTO Analysis subprogram's goals to: (1) support quantitative assessment of vehicle and mobility technology impacts and (2) provide insights into transportation and energy use problems for a broad range of stakeholders.

Reviewer 3:

This reviewer found that the project supports many of the energy and infrastructure objectives of VTO.

Reviewer 4:

This reviewer stated that the project is relevant to electrification.

Question 6: Please provide comments on the resources of the project. Are the resources sufficient for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer said that the resources for this project are sufficient.

Reviewer 2:

According to this reviewer, the resources are sufficient—each of the team members is an expert in the task allotted, and the accomplishments so far suggest that the work is getting done on pace with the project plan.

Reviewer 3:

The reviewer found that the resources appear sufficient, and that the project is on-time and on-budget.

Reviewer 4:

This reviewer believed that the resources provided seem sufficient for the scope of the project.

Acronyms and Abbreviations – VAN

Abbreviation	Definition
ACT	Advanced Clean Truck
CAR	Center for Automotive Research
COVID	Coronavirus disease (COVID-19), infectious disease caused by the SARS-CoV-2 virus
DOE	U.S. Department of Energy
DORMA	Decarbonization of Off-Road, Rail, Marine, and Aviation
U.S. DRIVE	United States Driving Research and Innovation for Vehicle Efficiency and Energy Sustainability
dsgrid-flex	NREL Demand Side Grid model
EEMS	VTO Energy Efficient Mobility Systems subprogram
EERPAT	Energy and Emissions Reduction Policy Analysis Tool
EV	Electric vehicle(s)
EVI-Pro	Electric Vehicle Infrastructure Projection Tool
EVI-X	Electric Vehicle Charging Infrastructure Analysis Tools
EVSE	Electric vehicle supply equipment
FHWA	Federal Highway Administration
HD	Heavy-duty
HEVI-LOAD	Heavy-Duty Electric Vehicle Load, Operations, and Deployment
ICE	Internal combustion engine
LD	Light-duty
MD	Medium-duty
NAICS	North American Industry Classification System
NREL	National Renewable Energy Laboratory
NYC	New York City
R&D	Research and development
ReEDS	Regional Energy Deployment System model
TAC	Technical advisory committee
TDM	Travel demand management
TEMPO	Transportation Energy and Mobility Pathway Options™
VAN	VTO Analysis subprogram
VMT	Vehicle miles travelled

Abbreviation	Definition
VTO	Vehicle Technologies Office
ZEV	Zero-emission vehicle

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8. Acronyms and Abbreviations

Abbreviation	Definition
0D	Zero-dimensional
1D	One-dimensional
21CTP	21st Century Truck Partnership
2-EHN	2-ethylhexyl nitrate
3D	Three-dimensional
^{7}Li NMR	Lithium nuclear magnetic resonance spectroscopy
A206	A206 composite matrix
AA7075	AA7075 aluminum alloy
AAM	American Axle and Manufacturing
AASHTO	American Association of State Highway and Transportation Officials
ABS	Acrylonitrile butadiene styrene
AC	Alternating current
ACM	American Center for Mobility
ACMZ	Aluminum-copper-manganese-zirconium
ACP50	Areas of concentrated poverty where 50% or more of residents are people of color
ACT	Advanced Clean Truck
ADAS	Advanced driver assistance system
ADOT	Alabama Department of Transportation
ADT	Articulated dump truck
AEC	Advanced Engine Combustion
AFLB	Anode-free lithium-ion batteries
AFV	Alternative fuel vehicle
AG	Artificial graphite
Ah	Ampere-hour
AI	Artificial intelligence
Al	Aluminum
ALD	Atomic layer deposition
ALS	Advanced Light Source

Abbreviation	Definition
AM	Additive manufacturing
AM20	AM20 magnesium cast alloy
AM50	AM50 magnesium cast alloy
AM60B	AM60B magnesium cast alloy
AMBER	Advanced Model Based Engineering Resource
AMR	Annual Merit Review
ANL	Argonne National Laboratory
APS	Advanced Photon Source
APU	Auxiliary power unit
ARC-M1	Army Research Combustor Midsize (ARC-M1)
ARL	Army Research Laboratory
ASE	Argyrodite-type solid electrolytes
ASIC	Application-specific integrated circuit
ASPIRE	Advancing Sustainability through Powered Infrastructure for Roadway Electrification
ASSLSB	All-Solid-State Lithium-Sulfur Battery
ASTM	ASTM International, formerly known as American Society for Testing and Materials
ATD	ATEAM Transmission Distribution
ATEAM	Agent-based Transportation Energy Analysis Model
AV	Autonomous vehicle
AZ91D	AZ91D magnesium cast alloy
B500	Battery 500 Consortium
BAAM	Big area additive manufacturing
BAs	Boron arsenide
BASF	BASF Corporation
BAT	Battery Advanced Technology, a DOE/VTO program
BaTiO3	Barium titanate
BCDI	Bragg coherent diffraction imaging
BEAM CORE	Behavior, Energy, Autonomy, and Mobility Comprehensive Regional Evaluator
BES	Basic Energy Sciences

Abbreviation	Definition
BEV	Battery electric vehicle
BFM	Bast fiber material
BGE	Baltimore Gas and Electric
BIL	Bipartisan Infrastructure Law
BIPOC	Black, indigenous, people of color
BMR	Battery Materials Research
BMS	Battery management system
BNL	Brookhaven National Laboratory
BOTTLE	Bio-Optimized Technologies to keep Thermoplastics out of Landfills and the Environment
BP	Budget Period
BTE	Brake thermal efficiency
BTM	Behind the meter
CAE	Computer aided engineering
CAM	Cathode active materials
CAMP	Cell Analysis, Modeling, and Prototyping (CAMP) Facility
CAPEX	Capital expenditure
CAR	Center for Automotive Research
CARB	California Air Resources Board
CAV	Connected and automated vehicle
CAVE	Connected and Automated Vehicle Environment
CBO	Community-based organization
CCD	Critical current density
CCF	Continuous carbon fiber
CDA	Cylinder deactivation
CDA	Cooperative driving automation
CE	Coulombic efficiency
CEI	Cathode electrolyte interphase
CF	Carbon fiber
CFD	Computational fluid dynamics
CFM	Carbon fiber mat

Abbreviation	Definition
CFRP	Carbon fiber reinforced polymer
CFTF	Carbon Fiber Technology Facility
CGM	Carbon-growth-on-metal
CI	Compression-ignition
CIM	Common information model
CMAP	Chicago Metropolitan Agency for Planning
CNG	Compressed natural gas
CNT	Carbon nanotube
CNT-S	Carbon nanotube-sulfur
Co	Cobalt
CO	Carbon monoxide
CO_2	Carbon dioxide
COMSOL	COMSOL Multiphysics ® modeling software
COOH	Carboxyl
COVID	Coronavirus disease (COVID-19), infectious disease caused by the SARS-CoV-2 virus
CQtCV	Constant lithium plating current (constant dQLi/dt) constant voltage
CRADA	Cooperative Research and Development Agreement
CRC	Coordinating Research Council
CSE	Center for Sustainable Energy
CSTR	Continuous stirred-tank reactor
CTA	Chicago Transit Authority
CTL	Compact track loader
Cu	Copper
CV	Connected vehicle
C-V2X	Cellular-vehicle-to-everything
DAB	Dual active bridge
DAC	Disadvantaged communities
DBC	Direct bonded copper
DC	Direct current
DCDI	Diffraction contrast diffractive imaging

Abbreviation	Definition
DCFC	Direct current fast charger
DEI	Diversity, Equity, and Inclusion
DER	Distributed energy resource(s)
DFI	Ducted fuel injection
DFT	Density functional theory
DHAM	Dual rotor homopolar AC machine
DHM	Digital holographic microscopy
DI	Direct injection
DLP	Digital light processing
DME	Dimethyl ether
DMSO/IL	Dimethyl sulfoxide/ionic liquid
DNS	Direct numerical simulation
DOC	Diesel oxidation catalyst
DOCF	Diesel oxidation catalyzed filter
DOE	U.S. Department of Energy
DORMA	Decarbonization of Off-Road, Rail, Marine, and Aviation
DoX	Design of experiment
dP/dV	Change in pressure with change in voltage
DPF	Diesel particulate filter
dQ/dV	Change in voltage with change in capacity
DRIVE	U.S. DRIVE
DRX	Disordered rock salt
DSF	Dynamic skip fire
dsgrid-flex	NREL Demand Side Grid model
DSRC	Dedicated short range communications
DST	Dynamic stress test
DVI	Drive vehicle interface
DVP&R	Design validation plan and report
DWG	Livewire Data Working Group
DWPT	Dynamic wireless power transfer
EaCAM	Earth-abundant cathode materials

Abbreviation	Definition
EB	Electron-beam
ECN	Engine Combustion Network
EDM	Electric drive machine
EDS	Energy-dispersive X-ray spectroscopy
EEAC	Energy Efficient Advance Compute
EEEJ	Energy equity and environmental justice
EEJ Action Plan	Energy Environmental Justice Action Plan
EEMS	Energy Efficient Mobility Systems
EERE	Office of Energy Efficiency and Renewable Energy
EERPAT	Energy and Emissions Reduction Policy Analysis Tool
EGR	Exhaust gas recirculation
EIC	Electron-Ion Collider
EIS	Electrochemical impedance spectroscopy
EJ	Environmental Justice
ELT	Electrification Technologies
EM	Electron microscopy
EMC	Electromagnetic compatibility
EMF	Electromagnetic field
EMI	Electromagnetic interference
EOCV	Electrochemical open circuit voltage
EOL	End-of-life
EP	Electropolymerization
EPA	U.S. Environmental Protection Agency
EPRI	Electric Power Research Institute
ESI/MS	Electrospray ionization / mass spectrometry
ESS	Energy storage system
EV	Electric vehicle(s)
EVAL	Electric Vehicle Adoption Leadership
EVI-Pro	Electric Vehicle Infrastructure Projection Tool
EVI-X	Electric Vehicle Charging Infrastructure Analysis Tools
EVSE	Electric vehicle supply equipment

Abbreviation	Definition
eVTOL	Electric vertical takeoff and landing
FAA	Federal Aviation Administration
FCA	Fiat Chrysler Automobiles
FCC	Federal Communications Commission
FCEB	Fuel cell electric bus
FCET	Fuel cell electric truck
FCEV	Fuel cell electric vehicle
FDMB	Fluoro-dimethoxylbutane
FEC	Fluoroethylene carbonate
Fe-zeolite	Iron zeolite
FHWA	Federal Highway Administration
FLHCE	Fluorinated lean high-capacity electrolyte
FMMB	2-Fluoro-1-methoxy-4-(methylsulfonyl)benzene, also known as FMMB, an organosulfur compound
FN	Foreign national
FOA	Funding opportunity announcement
FRA	Federal Railroad Administration
FSD	Tesla Full Self Driving
FSI	Fluoromethanesulfonimide
FSP	Flame spray pyrolysis
FSP	Friction stir processing
FTIR	Fourier transform infrared spectroscopy
FTP	Federal Test Procedure
FY	Fiscal Year
G3 5M	G3 5M steel alloy
GDOES	Glow discharge optical emission spectrometry
GE	General Electric, Inc.
GEM	Greenlink Equity Map
GHG	Greenhouse gas
GIXRD	Grazing incidence X-ray diffraction
GLOSA	Green light speed advisory

Abbreviation	Definition
GM	General Motors
GNSS	Global navigation satellite system
H11	H11 tool steel alloy
H_2	Hydrogen
H_2O	Water
HATCI	Hyundai America Technical Center, Inc
HATN	Hexaazatrinaphthylene
HATN/CNT	Hexaazatrinaphthylene/carbon nanotube
HATN/CNT-S	Hexaazatrinaphthylene/carbon nanotube-sulfur
HAXPES	Hard X-ray photoelectron spectroscopy
HBCU	Historically black colleges and universities
HD	Heavy-duty
HEV	Hybrid electric vehicle
HEVI-LOAD	Heavy-Duty Electric Vehicle Load, Operations, and Deployment
HFE	Fluorinated ether
HHEA	Hybrid hydraulic-electric architecture
HIL	Hardware-in-the-loop
HPDI	High-pressure direct injection
HPLC	High-performance liquid chromatography
HPM	High-performance modeling
HRE	Heavy rare earth
HTC	High temperature carbonization
HUD	U.S. Department of Housing and Urban Development
HV	High voltage
HVM	High-volume manufacturing
HVR	High-velocity riveting
I2V	Infrastructure to vehicle
IC	Ionic conductivity
ICE	Internal combustion engine
ICME	Integrated computation materials engineering
ID	Identification

Abbreviation	Definition
ID	Ignition delay
IEC	International Electric Code
i-EMS	Intelligent energy management system
IGBT	Insulated gate bipolar transistor
IIMo	Institute of Innovative Mobility (Germany)
IIT	Illinois Institute of Technology
INL	Idaho National Laboratory
IP	Internet protocol
IP	Intellectual property
IPM	Integrated power module
IRA	Inflation Reduction Act
ISO	International Standards Organization
ITIC	International Transportation Innovation Center
ITS	Intelligent transportation systems
Kg	Kilogram
kW	Kilowatt
kWh	Kilowatt-hour
L12	Phase of steel crystalline structure
L2	Level 2
LBL	Lawrence Berkeley National Laboratory
LBNL	Lawrence Berkeley National Laboratory
LC	Liquid chromatography
LCA	Life cycle analysis
LD	Light-duty
LDI	Lean direct injection (LDI)
LDP	Liveware Data Platform
LEEP	Leadership of Employers for Electrification Program
LES	Large eddy simulation
LFP	Lithium iron phosphate
LHCE	Lean high-capacity electrolyte
Li	Lithium

Abbreviation	Definition
Li_2S	Lithium sulfide
LIB	Lithium-ion battery
LiB_xS_y	Any compounds including lithium, boron and sulfur
LIC	Lithium-ion conductor
LiFSI	Lithium bis(fluorosulfonyl)imide
$LiNO_3$	Lithium nitrate
LiP_xS_y	Any compounds including lithium, phosphate and sulfur
LiS or Li-S	Lithium sulfur
LiTFSI	Lithium bis(trifluoromethanesulfonyl)imide
LLC	Limited liability corporation
LLCF	Low-lifecycle-carbon-fuels
LLNL	Lawrence Livermore National Laboratory
LLTO	Lithium lanthanum titanate oxide
LLZO	Lithium lanthanum zirconate
LLZTO	Garnet-type fast lithium-ion conductor $Li_{6.75}La_3Zr_{1.75}Ta_{0.25}O_{12}$
LMCP	Lightweight Metals Core Program
LMFP	Lithium iron phosphate ($LiFePO_4$) cathode material with manganese (Mn)
LMO	Lithium-ion manganese oxide
LMR	Lithium metal rich
LMR-NMC	Lithium manganese rich-nickel manganese cobalt material.
LNMO	Lithium-nickel-manganese oxide
LPG	Liquified petroleum gas or propane
LSE	Lithium solid electrolyte
LTE	A wireless data transmission standard
LTO	Lithium titanium oxide
mA	Milliampere
MAC-POST	Mobility Data Analytics Center-Prediction, Optimization, and Simulation toolkit for Transportation Systems
mAh	Milliampere-hour
MAN	MAN Energy Solutions
MAT	DOE VTO Materials subprogram

Abbreviation	Definition
MCA	Magnetocrystalline anisotropy
MCCI	Mixing-controlled compression ignition
MCS	Megawatt charging system
MD	Medium-duty
MDS	Mobility Data Specification
MeOH	Methanol
MEP	Mobility energy productivity
MERF	Materials Engineering Research Facility
METS	Multiharmonic electrothermal microscopy
MFH	Multi-family housing
Mg	Magnesium
MHP	Mixed hydroxide precipitate
MITIE	Micromobility-Integrated Transit and Infrastructure for Efficiency
ML	Machine learning
MMC	Metal matrix composites
Mn	Manganese
MoS2	Molybdenum disulfide
MPC	Model predictive control
MPG	Miles per gallon
MPO	Metropolitan planning organization
MR	Molecular Rebar®
MRL	Manufacturing readiness level
MS	Mass spectrometry
MTU	Michigan Technological University
MV	Medium voltage
MVA	Megavolt-ampere
MW	Megawatt
N/P	Negative-to-positive ratio
N_2O	Nitrous oxide
NAICS	North American Industry Classification System
NASA	National Aeronautics and Space Administration

Abbreviation	Definition
NC	Nitrogen doped (N-Doped) carbon
NCA	Nickel cobalt aluminum
NCM	Lithium nickel manganese cobalt oxides (abbreviated NMC, Li-NMC, LNMC, or NCM) are mixed metal oxides of lithium, nickel, manganese and cobalt
NCSU	North Carolina State University
NCTCOG	North Central Texas Council of Governments
NEVI	National Electric Vehicle Infrastructure
NFPA	National Fire Protection Association
NG	Natural gas
NGO	Non-government organization
NGV	Natural gas vehicle
NH_3	Ammonia
NH_4NO_3	Ammonium nitrate
NHTSA	National Highway Traffic Safety Administration
Ni	Nickel
$NiFe_2O_4$	Nickel ferrite
NIST	National Institute of Standards and Technology
NJFCP	National Jet Fuel Combustion Program
NMC	Nickel manganese cobalt
NMC622	6:2:2 ratio nickel manganese cobalt oxide
NMO	Nickel manganese oxide
NMP	N-methyl-2-pyrrolidone
NMR	Nuclear magnetic resonance spectroscopy
NMVC-R2	Nano- and micro-filler reinforced vitrimer composites using recycled milled carbon fibers
NN	Neural network
NO	Nitric oxide
NO_2	Nitrogen dioxide
NOx	Nitrogen oxides
NREL	National Renewable Energy Laboratory
NSF	National Science Foundation

Abbreviation	Definition
NSLS	National Synchrotron Light Source
NSP	Network service provider
NTCIP	National Transportation Communications for Intelligent Transportation System Protocol
NYC	New York City
NYPA	New York Power Authority
O_3	Ozone
OD	Origin-destination
ODBC	Organic direct bonded copper
OEM	Original equipment manufacturer
OH	Hydroxyl
OP2S	Opposed piston, two stroke
OPEX	Operational expense
ORNL	Oak Ridge National Laboratory
P2D	Pouch-to-depletion
PAEK	Polyaryletherketone
PAN	Polyacrylonitrile
PC	Polycarbonate
PC5	No base stationary intermediary in V2X LTE-Cellular protocol
Pd	Palladium
PDF	Pair distribution function
PE	Polyethylene
PECO	Formerly Philadelphia Electric Company
PEGDA	Polyethylene glycol diacrylate polymer
PET	Polyethylene terephthalate
PEV	Plug-in electric vehicle
PGM	Platinum group metals
PHEV	Plugin hybrid electric vehicle
PI	Principal investigator
PIV	Particle image velocimetry
PLA	Polylactic acid

Abbreviation	Definition
PM	Permanent magnet
PMCP	Powertrain Materials Core Program
PMP	Project management professional
PMTH	Thiuram polysulfides
PNA	Polynuclear aromatics
PNNL	Pacific Northwest National Laboratory
POFM	Porous organometallic framework materials
PP	Polypropylene
PR	Pooled rideshare
PRAM	Pooled rideshare acceptance model
PRCM	Pooled rideshare choice model
Pt	Platinum
PUA	Polyurethane acrylate
PUSP	Power ultrasonic-based surface processing
PV	Photovoltaic
PVDF	Polyvinylidene fluoride
PWA	Powdered activated carbon
PXRD	Powder X-ray diffraction
Q1, Q2, Q3, or Q4	Annual quarters
R&D	Research and development
RDD&D	Research, development, deployment, and demonstration
ReEDS	Regional Energy Deployment System model
Rh	Rhodium
RNG	Renewable natural gas
ROS	Robot operating system
RPT	Rate performance test
RQL	Rich-quench-lean (RQL) combustor
RSU	Single roadside unit
Ru	Ruthenium
RuO_2	Ruthenium oxide
S	Sulfur

Abbreviation	Definition
SAE	SAE International, formerly the Society of Automotive Engineers
SAF	Sustainable aviation fuel
SATF	Synthetic aviation turbine fuel
SBIR	Small Business Innovation Research
SCAQMD	South Coast Air Quality Management District
SCE	Combination of simulation and experiments
SCHT	Supercritical hydrothermal
SCM	Smart charge management
SCR	Selective catalytic reduction
SCRE	Single-cylinder research engine
SCSA	Sulfur cathode structure/architecture
SDF	Sudamericana de Fibras (company name)
SDO	Standards development organization
Se	Selenium
SEI	Solid-electrolyte interface/interphase
SEM	Scanning electron microscopy
SEMS	Site energy management system
SeS	Selenium sulfide
SFTP	Supplemental Federal Test Procedure
SHA	Single-hole atomizer
ShAPE	Shear assisted processing and extrusion
Si	Silicon
Si/Al	Silicon/aluminum
SiC	Silicon carbide
SIL	Software-in-the-loop
SLIC	Sustainable Lightweight Intelligent Composites
SLPC	Single-layer pouch cells
SMART	Systems and Modeling for Accelerated Research in Transportation
Sn	Tin
SNL	Sandia National Laboratories
SOC	State of charge

Abbreviation	Definition
SOH	State of health
SP	Solution precipitation
SPAN	Sulfurized polyacrylonitrile
SPC	Sulfurized polymer composite
SPE	Solid polymer electrolyte
SRM	Stochastic Reactor Model
SSB	Solid-state battery
SSCB	Solid-state circuit breaker
SSE	Solid-state electrolyte
SST	Solid-state transformer
SULEV30	Super-ultra-low emissions vehicle 30 standard
SUMO	Simulation of Urban Mobility
SUNY	The State University of New York
SUPER	Scalable ultra power-dense extended range
SwRI	Southwest Research Institute
T	Tesla
T4	T4 level of steel temper
T6	T6 level of steel temper
T76	T76 level of steel temper
TAC	Technical advisory committee
TCI	Lithium tricyanoimidazole
TCO	Total cost of ownership
TDM	Travel demand management
TEA	Techno-economic analysis
TEGDME	Tetra (ethylene glycol) dimethyl ether
TEM	Transmission electron microscopy
TEMPO	Transportation Energy and Mobility Pathway Options™
Tg	Glass transition temperature
TGA	Thermogravimetric analysis
TI	VTO Technology Integration subprogram
TiB_2	Titanium diboride

Abbreviation	Definition
TIM	Thermal interface material
ToF SIMS	Time-of-flight secondary ion mass spectrometry
TPG	Thermal pyritic graphite
TRL	Technology readiness level
TSDC	Transportation Secure Data Center
TSMO	Traffic system management and operations
TSMS	Transit-Centric Smart Mobility System
TTSI	Total Transportation Services, Inc.
TVR	Thermal vapor recompression
TWC	Three-way catalyst
U.S. DRIVE	United States Driving Research and Innovation for Vehicle efficiency and Energy sustainability
UA	University of Alabama
UC	University of California
UCC	Ultra conductive copper
UHMWPE	Ultra-high molecular weight polyethylene
UIC	The University of Illinois at Chicago
UIUC	The University of Illinois Urbana-Champaign
ULEV	Ultra-low emissions vehicle
UMD	University of Maryland
UNT	University of North Texas
UPER	Universal power electronics regulator
URJ	Ultrasonic rivet joining
US	United States
US06	EPA US06, also known as the Supplemental Federal Test Procedure
USA	United States of America
USABC	U.S. Department of Energy/U.S. Advanced Battery Consortium, a subsidiary of USCAR
USC	University of Southern California
USDA	U.S. Department of Agriculture
USW	Ultrasonic welding
Uu	Cellular network communications

Abbreviation	Definition
UV	Ultraviolet
UW	University of Washington
V2G	Vehicle to grid
V2I	Vehicle-to-infrastructure
V2V	Vehicle-to-vehicle
V2X	Vehicle-to-everything
VAN	VTO Analysis (VAN) program
VECTOR	Visual-Enhanced Cooperative Traffic Operations
VED	Volumetric energy density
VGI	Vehicle grid integration
VMT	Vehicle miles travelled
VoICE-MR	Vocation Integrated Cost Estimation for Maintenance and Repair
VPPG	Virtual and Physical Proving Ground
VTO	Vehicle Technologies Office
VTTI	Virginia Tech Transportation Institute
W	Tungsten
WAVE	Wireless Advanced Vehicles Electrification
WBG	Wide bandgap
WFSM	Wound-field synchronous machine
WHR	Waste heat recovery
WLTC	Worldwide Harmonized Light Vehicles Test Cycle
WPT	Wireless power transfer
WVU	West Virginia University
WXFC	Wireless extreme fast charge
XAS	X-ray absorption spectroscopy
XCEL	eXtreme Fast Charge Cell Evaluation of Lithium-Ion Batteries
XFC	Extreme fast charging
XIL	Everything-in-the-loop
XPS	X-ray photoelectron spectroscopy
XRD	X-ray diffraction
XRD/XAS	X-ray Diffraction/X-ray Absorption Spectroscopy

Abbreviation	Definition
ZECT	Zero emission cargo transport
ZEV	Zero-emission vehicle

U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

For more information, visit:
energy.gov/eere/vehicles

DOE/EE-2840• May 2024