U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

2015 Annual Merit Review, Vehicle Technologies Office

Results Report

November 2015

Prepared by New West Technologies, LLC for the U.S. Department of Energy Vehicle Technologies Office

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Introduction

The 2015 U.S. Department of Energy (DOE) Fuel Cell Technologies Office (FCTO) and Vehicle Technologies Office (VTO) Annual Merit Review and Peer Evaluation Meeting (AMR) was held June 8-12, 2015, in Arlington, Virginia. The review encompassed work done by the FCTO and the VTO: 258 individual activities were reviewed for VTO, by 170 reviewers. A total of 1,095 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 on the Office with a structured and formal methodology. The meeting also provided attendees with a forum for interaction and technology information transfer.

The peer review process followed the guidelines of the Peer Review Guide developed by the Office of Energy Efficiency and Renewable Energy (EERE). Each activity is reviewed every three years, at a minimum. However, the Office 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. A complete list of the meeting participants is presented as Appendix A.

Evaluation Criteria – Research & Development Subprogram Projects

In the technical research and development (R&D) subprogram sessions, these 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 project reviews, including any American Recovery and Reinvestment Act (ARRA) reviews.

Question 1. Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts. (Scoring weight for overall average = 20%)

- 4.0=outstanding (sharply focused on critical barriers; difficult to improve approach 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 toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress toward DOE goals. (Scoring weight for overall average = 40%)

- 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 with other institutions. (Scoring weight for overall average = 10%)

- 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 fairly 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—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways. (Scoring weight for overall average = 10%)

- 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 5. Does this project support the overall DOE objectives of petroleum displacement? Why or why not? (Scoring weight, not included with overall average = 20%)

- yes
- no

Question 6. Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

- excessive
- sufficient
- insufficient

Evaluation Criteria – Technology Integration Projects

Reviewers for the Technology Integration (TI) technical session answered questions tailored to TI's 2015 AMR focus on petroleum reduction technologies and practices, alternative fuels, infrastructure, and related efforts. These technical questions are listed below, along with appropriate scoring metrics.

Question 1. Project approach to supporting deployment of petroleum reduction technologies and practices, alternative fuel vehicles, infrastructure and related efforts—the degree to which the project is well-designed, feasible, and integrated with other efforts. (Scoring weight for overall average = 20%)

- 4.0=outstanding (difficult to improve project approach significantly).
- 3.0=good (generally effective but could be improved).
- 2.0=fair (has significant weaknesses).
- 1.0=poor (not responsive to project objectives).

Question 2. Project accomplishments and progress toward overall project and DOE goals—the degree to which progress/significant accomplishments have been achieved, measured against performance indicators and demonstrated progress toward project and DOE goals. (Scoring weight for overall average = 40%)

- 4.0=outstanding (excellent progress toward objectives).
- 3.0=good (significant progress toward objectives).
- 2.0=fair (rate of progress has been slow).
- 1.0=poor (little or no progress towards objectives).

Question 3. Collaboration and Coordination among the Project Team—the degree to which the appropriate team members and partners are involved in the project work and the effectiveness of collaboration between and among partners. (Scoring weight for overall average = 10%)

- 4.0=outstanding (close, appropriate collaboration within project team; team members are well-suited to effectively carry out the work of the project).
- 3.0=good (some collaboration exists; team members are fairly well-suited to project work).

- 2.0=fair (a little collaboration exists; team membership could be improved).
- 1.0=poor (little or no apparent collaboration between team members; project team is lacking critical expertise to effectively carry out the work of the project).

Question 4. Alternative Fuel Market Expansion and/or Petroleum Reduction Potential—the degree to which the project has the potential to contribute to a sustainable alternative fuel vehicle market and/or reduce petroleum dependence in the transportation sector, including the potential to reduce barriers to large scale alternative fuel vehicle market penetration and make information about alternative fuels and petroleum reduction opportunities widely available to target audiences. (Scoring weight for overall average = 10%)

- 4.0=outstanding (Project clearly contributes to alternative fuel vehicle market expansion and/or petroleum reduction; project is sharply focused on barriers and provides highly effective and widely available information resources.).
- 3.0=good (project has the potential to contribute to alternative fuel vehicle market expansion and/or petroleum reduction; project generally addresses overcoming barriers and provide for public information needs.).
- 2.0=fair (Project may lead to market improvements and petroleum reduction, but needs better focus on overcoming barriers and providing information.).
- 1.0=poor (Project has little relevance toward advancing an alternative fuel vehicle market or reducing petroleum consumption; project fails to eliminate barriers or inform appropriate audiences).

Question 5. Relevance—Does this project support the overall DOE objectives of reducing reliance on petroleum based fuels? Why or why not? (Scoring weight for overall average = 20%)

- yes
- no

Question 6. Use of resources—Are DOE funds being used wisely? Should DOE fund similar efforts in the future? If not, what would be a better use of DOE resources to achieve alternative fuel vehicle and infrastructure expansion?

- yes
- maybe
- no

Project Scoring

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:

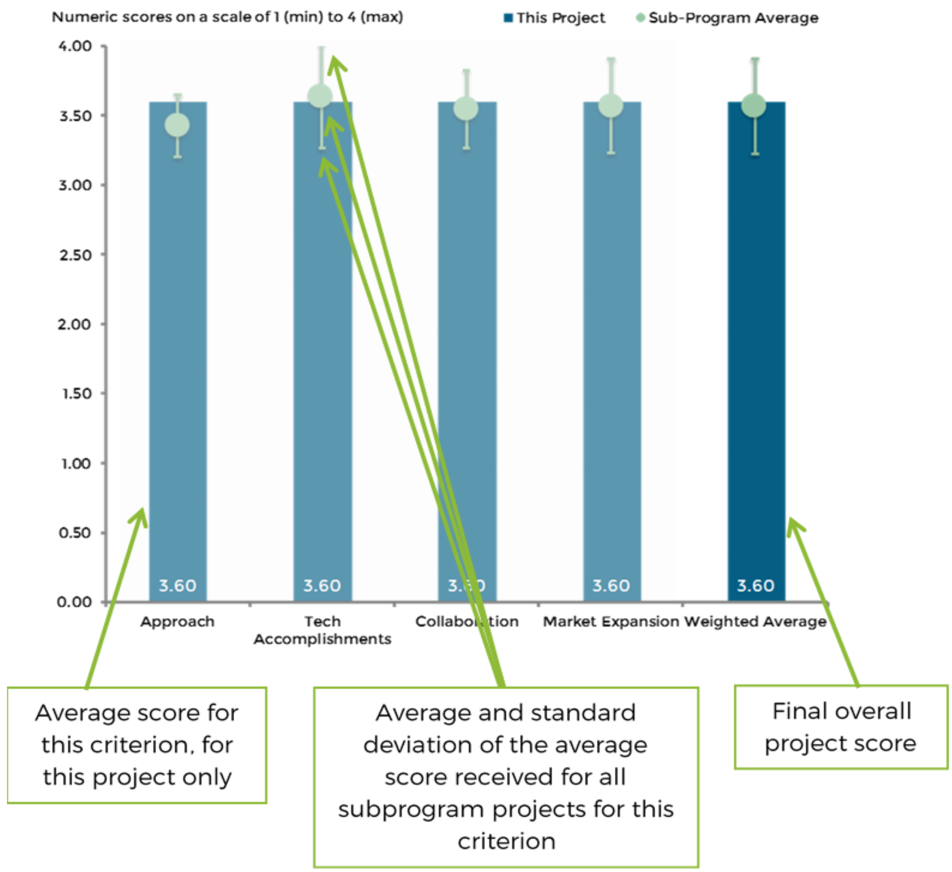

Figure 1: Sample Question 1 through Question 4 score averages, standard deviations, and overall Weighted Average for a TI project

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 red 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.

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 because the scoring scales are incompatible. As demonstrated in Figure 2, each reviewed activity has pie charts representing that project's population distributions for each reviewer rating associated with Question 5 and Question 6:

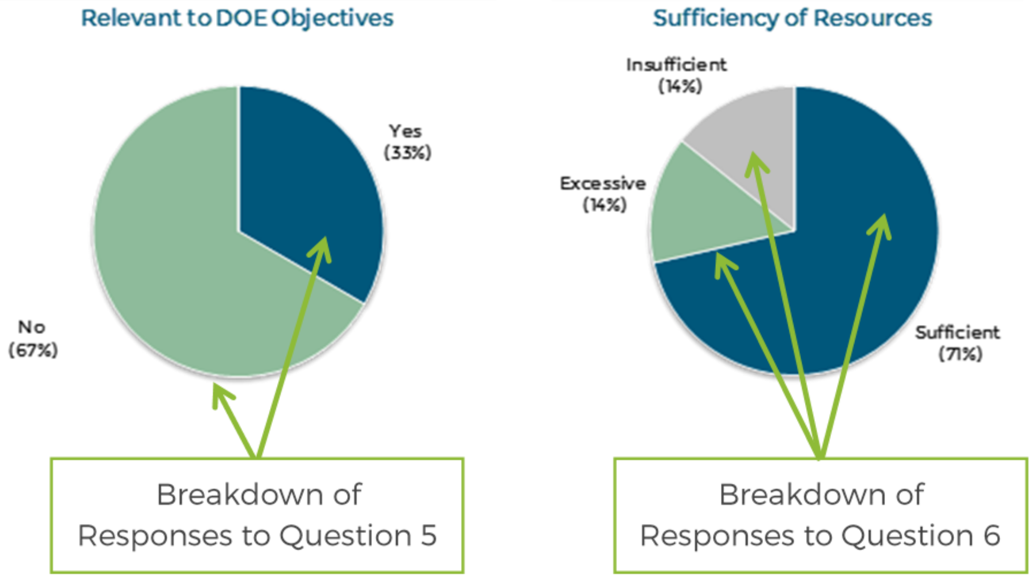

Figure 2: Sample Question 5 and Question 6 population distributions for R&D subprogram project

For TI projects, Question 1 through Question 4 were rated on a 1.0 to 4.0 scale in one-point increments, whereas Question 5 was rated on a yes or no scale, and Question 6 was rated on a yes, maybe, or no scale. Consequently, Question 5 and Question 6 results were excluded from the Weighted Average calculation because the scoring scales are incompatible. Similar to the R&D subprograms, each reviewed activity for TI projects has pie charts representing that project's population distributions for each reviewer rating associated with Question 5 and Question 6.

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 the project title, followed by the Principal Investigator (PI), the PI's organization, and the project identification (ID) number. For each subprogram area, reviewed activities are ordered numerically by project number. Figure 3, below, provides an example project title:

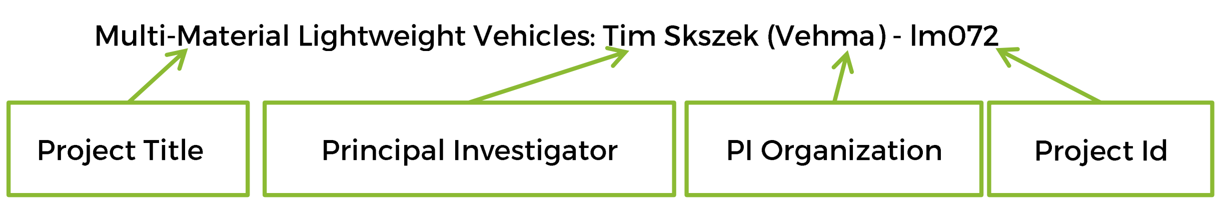

Figure 3: Sample project title with project title, PI, PI organization, and project number

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, reviewer feedback received specific to the subprogram overview presentation(s) given by DOE, a subprogram activities score summary table (and page numbers), and project-specific reviewer evaluation comments with corresponding bar and pie charts.

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1. Vehicle Systems

Hybrid and vehicle systems research provides an overarching vehicle systems perspective to the technology research and development (R&D) activities of the U.S. Department of Energy's (DOE's) vehicle research programs, and identifies major opportunities for improving vehicle efficiencies. The effort evaluates and validates the integration of technologies, provides component and vehicle benchmarking, develops and validates heavy hybrid propulsion technologies, and develops technologies to reduce the parasitic losses from heavy vehicle systems. Analytic and empirical tools are used to model and simulate potential vehicle systems, validate component performance in a systems context, benchmark emerging technology, and validate computer models. Extensive collaboration with the technology development activities is required for success. The results of hybrid and vehicle systems activities are used to estimate the national benefits and impacts of DOE-sponsored technology development, and successfully transfer developed technology to industry.

In August 2009, the DOE announced the selection of 10 projects totaling $425 million for development, deployment, and validation of hybrid vehicles, and deployment of charging stations across the nation. American Reinvestment and Recovery Act (ARRA)-funded transportation electrification activities will aid in the deployment of technologies that help to reduce petroleum consumption. Activities include deployment of 18,000 public and private charging stations in major metropolitan areas across the country, and deployment of truck stop electrification infrastructure at 50 sites across interstate corridors. Additional deployment activities include development, validation, and deployment of light- and medium-duty electric drive vehicles.

Subprogram Feedback

DOE received feedback on the overall technical subprogram areas presented during the 2015 Annual Merit Review (AMR). Each subprogram technical session was introduced with a presentation that provided an overview of subprogram goals and recent progress, followed by a series of detailed topic area project presentations.

The reviewers for a given subprogram area responded to a series of specific questions regarding the breadth, depth, and appropriateness of that DOE VTO subprogram's activities. The subprogram overview questions are listed below, and it should be noted that no scoring metrics were applied. These questions were used for all VTO subprogram overviews.

Question 1. Was the program area, including overall strategy, adequately covered?

Question 2. Is there an appropriate balance between near- mid- and long-term research and development?

Question 3. Were important issues and challenges identified?

Question 4. Are plans identified for addressing issues and challenges?

Question 5. Was progress clearly benchmarked against the previous year?

Question 6. Are the projects in this technology area addressing the broad problems and barriers that the Vehicle Technologies Office (VTO) is trying to solve?

Question 7. Does the program area appear to be focused, well-managed, and effective in addressing VTO's needs?

Question 8. What are the key strengths and weaknesses of the projects in this program area? Do any of the projects stand out on either end of the spectrum?

Question 9. Do these projects represent novel and/or innovative ways to approach these barriers as appropriate?

Question 10. Has the program area engaged appropriate partners?

Question 11. Is the program area collaborating with them effectively?

Question 12. Are there any gaps in the portfolio for this technology area?

Question 13. Are there topics that are not being adequately addressed?

Question 14. Are there other areas that this program area should consider funding to meet overall programmatic goals?

Question 15. Can you recommend new ways to approach the barriers addressed by this program area?

Question 16. Are there any other suggestions to improve the effectiveness of this program area?

Responses to the subprogram overview questions are summarized in the following pages. Individual reviewer comments for each question are identified under the heading Reviewer 1, Reviewer 2, etc. Note that reviewer comments may be ordered differently; for example, for each specific subprogram overview presentation, the reviewer identified as Reviewer 1 in the first question may not be Reviewer 1 in the second question, etc.

Subprogram Overview Comments: David Anderson (U.S. Department of Energy) – vss000

Question 1: Was the program area, including overall strategy, adequately covered?

Reviewer 1:
The reviewer said that the background overview was adequately provided along with the objectives.

Reviewer 2:
The reviewer responded yes, and commented that it is very difficult to share so much in such a short time. Slides here are meant to inform for future reference maybe rather than to be good presentation slides for sharing information at the event. The reviewer thought that this is fine for this sort of overview. The reviewer suggested that it might help to more clearly identify the budget levels for the various levels and for the past, present and future budget years.

Question 2: Is there an appropriate balance between near- mid- and long-term research and development?

Reviewer 1:
The reviewer said that there is an attempt to have a balance between the near-, mid- and long-terms, but the challenge is bridging the development to realize the benefits into the vehicle level system.

Reviewer 2:
The reviewer thought there is an appropriate balance, and elaborated that this was difficult to understand when the reviewer first began attending and participating in the 21st Century Truck Partnership (21CTP). The reviewer has found the research, development, design, and deployment chart to be useful. The reviewer suggested that maybe a chart that lays out the major areas on such a timeline would help.

Question 3: Were important issues and challenges identified?

Reviewer 1:
The reviewer said that different focus areas are linked together to achieve the overall Vehicle & System Simulation (VSS) objectives. The reviewer said that results and data are developed and shared; this serves the ability to validate the results.

Reviewer 2:
The reviewer was unsure if issues and challenges were identified. This seemed to be more of an informing and sales presentation rather than one that discusses challenges on the projects. The reviewer suggested maybe one slide and two minutes to expand this thought, or ignore it.

Question 4: Are plans identified for addressing issues and challenges?

Reviewer 1:
The reviewer indicated that some of the issues and challenges were highlighted, but concrete plans to address them were not illustrated.

Reviewer 2:
The reviewer said that plans were not really identified, other than at a very high level.

Question 5: Was progress clearly benchmarked against the previous year?

Reviewer 1:
The reviewer said yes, and elaborated that there is clear evidence of the system approach taken.

Reviewer 2:
The reviewer said yes, and explained that there was noted continuance of various projects such as SuperTruck.

Question 6: Are the projects in this technology area addressing the broad problems and barriers that the Vehicle Technologies Office (VTO) is trying to solve?

Reviewer 1:

The reviewer said yes, in almost every focus area, the VSS portfolio supports many activities. The reviewer pointed out that the presenter was very specific in illustrating the different projects and their benefits.

Reviewer 2:

The reviewer said yes, and explained that it was and is obvious that the focus of this organization is petroleum reduction across the vehicle sectors and that it spans research to deployment.

Question 7: Does the program area appear to be focused, well-managed, and effective in addressing VTO's needs?

Reviewer 1:

The reviewer said yes, the team and the management appear to have a good understanding of the challenges and what to focus on; the team is covering all areas of the portfolio projects.

Reviewer 2:

The reviewer commented yes, albeit difficult with such a broad focus. Sometimes this reviewer sees some projects that seem to go on in perpetuity in some specific areas.

Question 8: What are the key strengths and weaknesses of the projects in this program area? Do any of the projects stand out on either end of the spectrum?

Reviewer 1:

The reviewer indicated that the Vehicle Technology evaluation along with the data collected is very useful, and serves many benefits. The reviewer pointed out that Modeling and Simulation approach and the tools used are very useful.

Reviewer 2:

The reviewer said that strengths are when a project quickly develops the understanding, solutions and tools quickly in a particular area and then makes it available to developers or end users for true deployment. The reviewer noted that true change must follow it into the hands of users and this can be very difficult and time-consuming.

Question 9: Do these projects represent novel and/or innovative ways to approach these barriers as appropriate?

Reviewer 1:

The reviewer agreed that the projects do have benefits, and the approach taken is very innovative. The reviewer elaborated that the key aspect that needs to be explained is how these benefits and associated findings are being used by the industry.

Reviewer 2:

The reviewer sees many innovative ways to approach barriers, and pointed out Cool Cab as an example.

Question 10: Has the program area engaged appropriate partners?

Reviewer 1:

The reviewer responded yes, and pointed out the different DOE laboratories, academia and industry.

Reviewer 2:

The reviewer thought so, though this is difficult to measure. Each program needs to continue to be evaluated on this topic. According to the reviewer, a reviewer can generally tell pretty easily if the Principal Investigator is proud of or embarrassed by how well the project team collaborates with their partners.

Question 11: Is the program area collaborating with them effectively?

Reviewer 1:

The reviewer said yes, and commented that there is a clear evidence of the collaboration between the different areas and partners.

Reviewer 2:

The reviewer elaborated that some projects display effective collaboration, others very poorly. This reviewer noted this on each project review.

Question 12: Are there any gaps in the portfolio for this technology area?

Reviewer 1:

This reviewer would like to see integrating all the component level and simulation into a single vehicle to determine the true benefits for technology improvement, efficiency, system cost, and weight reduction.

Reviewer 2:

This reviewer suggested keeping a focus on efficiency as a strategy and not diverting too much attention to alternative fuels, etc.

Question 13: Are there topics that are not being adequately addressed?

Reviewer 1:

The reviewer thought the overview was very comprehensive, from a high level. The reviewer noted that specific details and data were not provided, something that would have been good to see from a comparison to last year's activities.

Question 14: Are there other areas that this program area should consider funding to meet overall programmatic goals?

Reviewer 1:

The reviewer suggested staying focused on tractor-trailers with so much fuel being used.

Reviewer 2:

The reviewer pointed out that one area of interest is to evaluate different vintages of vehicles with similar technologies produced in different periods, and see what changed in the areas of weight, cost, efficiencies, and consumer acceptance. The reviewer also suggested assessing how the simulation and modeling tools measure against the actual physical design.

Question 15: Can you recommend new ways to approach the barriers addressed by this program area?

Reviewer 1:

This reviewer prefers seeing the VSS overview at the end of the individual VSS project reviews at the Annual Merit Review; this way the overall achievements can be reviewed after the specific projects have been illustrated.

Question 16: Are there any other suggestions to improve the effectiveness of this program area?

Reviewer 1:

The reviewer recommends continuing with the VSS projects; the benefits realized toward the goals are seen in many areas. The reviewer would like to see more comparative data, in both the components and vehicle level, evaluating current production vehicles and how they measure against the funded areas.

Reviewer 2:

The reviewer suggested marketing this review a little more to those organizations that can help deliver desired change (i.e., software/app developers, marketing people, leaders at the truck builders who integrate so many of these technologies, and fleets).

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.

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Class 8 Truck Freight Efficiency Improvement Project	Rotz, Derek (DTNA)	1-14	4.00	3.83	3.83	3.83	3.88
Plug-In Hybrid Medium-Duty Truck Demonstration and Evaluation Program	Myasato, Matt (SCAQMD)	1-16	3.00	3.10	3.20	3.00	3.08
Medium- and Heavy-Duty Vehicle Field Evaluations	Kelly, Ken (NREL)	1-20	3.75	3.75	3.75	3.50	3.72
DOE's Effort to Improve Heavy Vehicle Fuel Efficiency through Improved Aerodynamics	Salari, Kambiz (LLNL)	1-23	3.38	3.13	3.13	3.38	3.22
Idaho National Laboratory Testing of Advanced Technology Vehicles	Shirk, Matthew (INL)	1-27	3.38	3.75	3.25	3.13	3.52
Advanced Vehicle Testing and Evaluation	Jacobson, Richard (Intertek)	1-30	2.80	2.80	3.60	3.10	2.94

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Advanced Technology Vehicle Lab Benchmarking (L1 and L2)	Stutenberg, Kevin (ANL)	1-34	3.10	3.50	3.00	3.00	3.28
Development of High-Power Density Driveline for Vehicles †	Ajayi, Oyelayo (ANL)	1-37	3.00	2.67	3.00	2.67	2.79
SuperTruck - Development and Demonstration of a Fuel-Efficient Class 8 Tractor and Trailer	Zukouski, Russ (Navistar)	1-39	3.13	2.88	3.25	3.13	3.02
CoolCab Test and Evaluation and CoolCalc HVAC Tool Development	Lustbader, Jason (NREL)	1-42	3.83	3.67	3.67	3.50	3.69
A Complete Vehicle Approach to the SuperTruck Challenge	Amar, Pascal (Volvo Trucks)	1-45	3.33	3.17	3.33	3.33	3.25
EV - Smart Grid Research and Interoperability Activities †	Hardy, Keith (ANL)	1-47	3.50	3.50	3.40	3.10	3.44
Testing of Wireless Charging Systems for Codes and Standards Development	Carlson, Barney (INL)	1-50	3.67	3.83	3.17	3.83	3.71
Electric Drive Vehicle Climate Control Load Reduction	Rugh, John (NREL)	1-53	3.50	3.17	3.00	3.00	3.21

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
High-Efficiency, Low-EMI and Positioning Tolerant Wireless Charging of EVs	Lewis, Allan (Hyundai)	1-55	3.38	3.38	3.13	3.25	3.33
Wireless Charging	Onar, Omer (ORNL)	1-58	3.00	3.50	3.13	3.13	3.28
Zero-Emission Heavy-Duty Drayage Truck Demonstration	Choe, Brian (SCAQMD)	1-61	2.67	2.67	3.00	2.83	2.73
Zero-Emission Cargo Transport Deployment Projects	Williams, Nicholas (Houston-Galveston Area Council)	1-64	2.13	2.00	2.25	2.38	2.11
Thermal Control Projects	Singh, Dileep (ANL)	1-67	2.80	3.00	2.70	3.00	2.91
Cummins MD & HD Accessory Hybridization CRADA	Deter, Dean (ORNL)	1-71	3.20	3.30	3.30	3.00	3.24
Vehicle Thermal Systems Modeling in Simulink	Lustbader, Jason (NREL)	1-75	3.50	3.50	3.75	3.50	3.53
Advanced Climate Control and Vehicle Preconditioning	Meyer, John (Halla Visteon)	1-78	3.25	3.25	2.88	3.25	3.20
Electric Phase Change Material Assisted Thermal Heating System (ePATHS)	Wang, Mingyu (Delphi Automotive Systems, LLC)	1-81	3.17	3.33	3.50	3.17	3.29

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Impacts of Advanced Combustion Engines †	Curran, Scott (ORNL)	1-83	3.63	3.50	3.13	3.25	3.45
Powertrain Controls Optimization for Heavy-Duty Line Haul Trucks	Smith, David (ORNL)	1-86	3.38	3.13	3.38	3.13	3.22
Integration of PEVs with the Grid †	Pratt, Richard (PNNL)	1-89	3.25	3.25	2.75	3.25	3.19
Powertrain Codes and Standards Development	Duoba, Mike (ANL)	1-92	3.13	3.38	3.25	3.13	3.27
Green Racing Protocols and Technology Applications	Jones, Perry (ORNL)	1-94	3.30	3.30	3.30	3.20	3.29
Technology Requirements for High-Power Applications of Wireless Power Transfer	Onar, Omer (ORNL)	1-99	3.38	3.38	2.38	3.25	3.23
Accelerate the Development and Introduction of Advanced Technologies through Model-Based System Engineering	Rousseau, Aymeric (ANL)	1-102	2.90	2.90	2.90	3.00	2.91

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Fuel Displacement Potential of Advanced Technologies under Different Thermal Conditions	Rousseau, Aymeric (ANL)	1-106	2.90	3.00	3.00	2.90	2.96
Analyzing Real-World Light-Duty Vehicle Efficiency Benefits	Gonder, Jeff (NREL)	1-110	3.50	3.30	3.00	3.30	3.31
Smart Grid Requirements Study	Markel, Tony (NREL)	1-113	2.83	2.67	2.83	2.50	2.71
Unitary Thermal Energy Management for Propulsion Range Augmentation (UTEMPRA)	Chowdhury, Sourav (Delphi Automotive Systems, LLC)	1-116	3.50	3.50	3.00	3.17	3.40
Zero-Emission Cargo Transport Projects (ZECT)	Cole, Nancy (SCAQMD)	1-118	3.25	3.13	3.38	3.25	3.20
Medium-Duty ARRA Data Reporting and Analysis	Kelly, Ken (NREL)	1-121	3.75	3.63	3.75	3.38	3.64
Fleet DNA Phase 1 Refinement & Phase 2 Implementation	Kelly, Ken (NREL)	1-123	3.88	3.75	3.75	3.63	3.77
Multi-Speed Gearbox for Commercial Delivery Medium-Duty Plug-In Electric Drive Vehicles	Chavdar, Bulent (Eaton)	1-126	3.25	3.13	3.13	3.13	3.16

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Integrated Boosting and Hybridization for Extreme Fuel Economy and Downsizing	Tsourapas, Vasilios (Eaton)	1-129	3.25	3.25	2.88	3.13	3.19
Advanced Bus and Truck Radial Materials for Fuel Efficiency	Martin, Justin (PPG)	1-132	3.17	3.33	2.83	3.33	3.23
Evaluate VTO Benefits (BaSce) †	Shidore, Neeraj (ANL)	1-135	3.13	3.38	3.25	3.25	3.28
Design and Implementation of a Thermal Load Reduction System in a Hyundai PHEV to Improve Range †	Rugh, John (NREL)	1-138	3.75	3.38	3.75	3.63	3.55
Advanced Transmission Selection to Provide Accurate VTO Benefits †	Shidore, Neeraj (ANL)	1-141	3.25	3.50	3.25	3.25	3.38
Integrated Network Testbed for Energy Grid Research and Technology Experimentation (INTEGRATE) †	Hunter, Brian (NREL)	1-143	3.25	3.25	3.50	3.25	3.28
Accessory Loads Analysis †	Carlson, Richard (INL)	1-146	3.25	3.38	2.75	2.75	3.19
PEV-EVSE Interoperability Project †	Jacobson, Richard (Intertek)	1-148	3.70	3.40	3.80	3.50	3.54

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Lessons Learned about Workplace Charging in The EV Project †	Smart, John (INL)	1-152	3.38	3.13	3.50	3.25	3.25
eVMT (Electric Vehicles Miles Traveled) †	Carlson, Richard (INL)	1-155	3.50	3.50	3.75	3.50	3.53
Overall Average			**3.29**	**3.27**	**3.22**	**3.19**	**3.26**

Note: † denotes poster presentation.

Class 8 Truck Freight Efficiency Improvement Project: Derek Rotz (DTNA) - arravt080

Presenter

Derek Rotz, DTNA.

Reviewer Sample Size

A total of three reviewers evaluated this project.

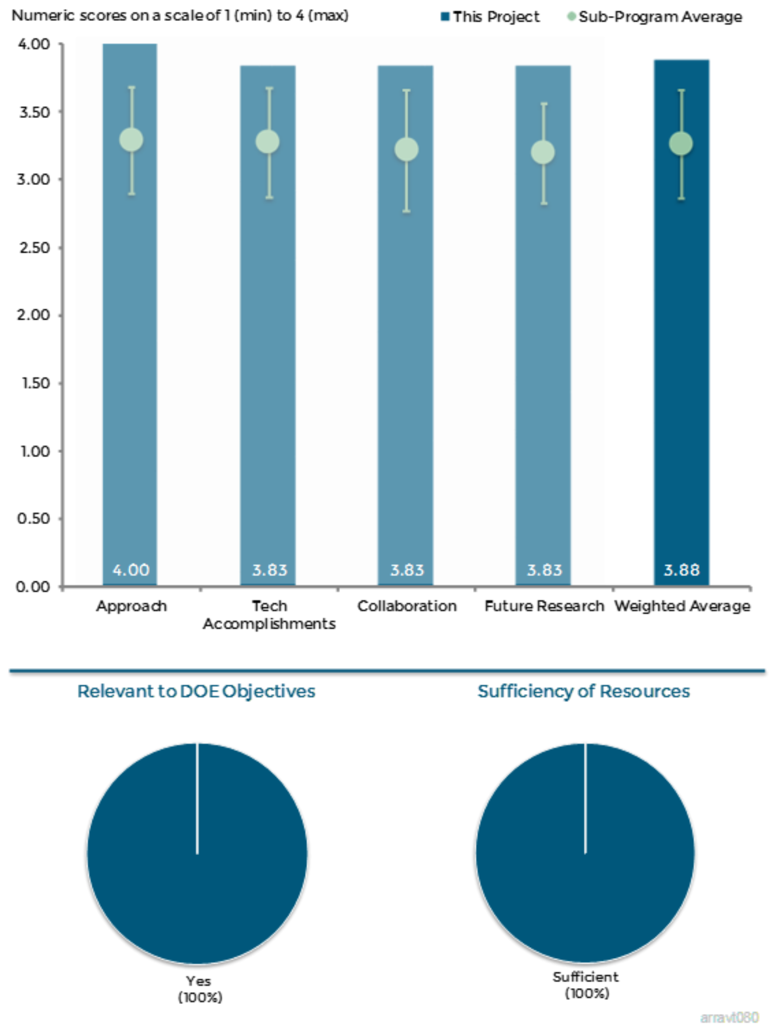


Figure 1-1 Class 8 Truck Freight Efficiency Improvement Project: Derek Rotz (DTNA) - Vehicle Systems

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer found the project team’s approach as evidenced in every Annual Merit Review (AMR) to be outstanding. The project team made hard tradeoff choices along the way, always sharing the right level of detail. The reviewer noted the project team had a nice presentation/unveiling at Mid America Truck Show in Louisville. The reviewer stated that the project helped to prove that SuperTruck is not just a research and development (R&D) project but an incubator and demonstrator of real technologies available now and soon.

Reviewer 2:

The reviewer indicated that the approach taken is very comprehensive, including many beyond state-of-the-art technologies from engine to vehicles, allowing this project to well over-achieve the program goals. While many of the technologies are not commercially viable even in 2025-2030 time frame, such as those super-light materials and hybrids, it does clearly demonstrate the roadmap to achieve the program goals. The reviewer stated that the project is very well done; however, there is no noticeable benefit with hybrid. In particular, this approach may conflict with eCoast because eCoast wants to minimize braking for optimal efficiency, while hybrid wants to recover most of the braking energy. The reviewer added that one can imagine that this program can even do a much better job if the funding is not used for hybrid.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer said 12 miles per gallon (mpg), wow, well done. The reviewer stated that the project team used this program and its resources to tackle many of the major tradeoff decisions. Distributed cooling, aggressive aerodynamics, e-coast and/or hybridization, waste heat recovery (WHR), and on and on. The reviewer added that the project team were very aggressive on mpg and ton-mile/gallon even with unaffordable technologies. The project team clearly went aggressively after all that is possible rather than stopping at the requirement. The reviewer appreciated the green, yellow, red clarification of commercially available technologies. The reviewer stated that the project team could have gone one level deeper and included mpg predictions for the three scenarios, red, yellow and green, which would have taken this to outstanding.

Reviewer 2:

The reviewer remarked that achieving 12.2 mpg regardless of what kinds of beyond state-of-the-art technologies is an unbelievable achievement. This program also demonstrates great potential with their eCoast technology that could be put into production. The reviewer added that it is still questionable what kind of achievement a hybrid can make from this project.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that the list of collaborators is very extensive and evidence that all have benefited from this experience.

Reviewer 2:

The reviewer said that it is great to see that the program has used many partners.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer commented that even though the project is concluded, there is evidence that work will continue.

Reviewer 2:

The reviewer pointed out that the mission is accomplished, and no more on the future work.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer noted great mpg gains.

Reviewer 2:

The reviewer said yes, many technologies developed under this program, such as eCoast, can bring immediate impact on supporting the overall U.S. Department of Energy (DOE) objective of petroleum displacement.

Reviewer 3:

The reviewer pointed out that Class 8 heavy-duty (HD) tractor-trailers are a huge opportunity.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said well done.

Plug-In Hybrid Medium-Duty Truck Demonstration and Evaluation Program: Matt Myasato (SCAQMD) - arravt083

Presenter

Matt Myasato, SCAQMD.

Reviewer Sample Size

A total of five reviewers evaluated this project.

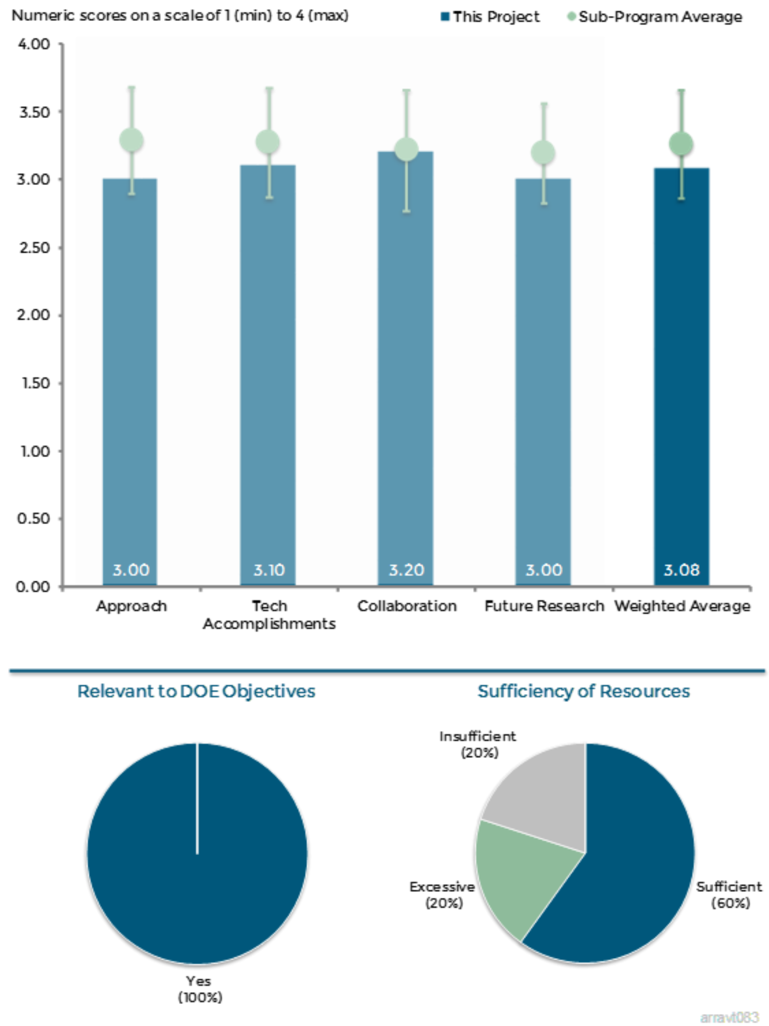


Figure 1-2 Plug-In Hybrid Medium-Duty Truck Demonstration and Evaluation Program: Matt Myasato (SCAQMD) - Vehicle Systems

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that as this project reaches the very data- driven commercial industry, it has great importance to produce accurate data to support economic investment in the future.

Reviewer 2:

The reviewer noted that the project is nearly complete, with most deliverables met. Better data collection and analysis are required.

Reviewer 3:

The reviewer indicated that a good partner selection allowed vehicles to be acquired and placed into operation for field data collection and technology evaluation. As this is a late phase report, the approach was not fully detailed in this presentation. The reviewer added that some trucks will be deployed during the month of June, but the project ends in July, so there will be limited time for data collection in some types of trucks.

Reviewer 4:

The reviewer reported that the approach is good, shows performance and use across many vocations and locations. Smart charging and battery sizing were considered for the variety of operation.

Reviewer 5:

The reviewer reported that the overall approach summary included designing, developing and deploying plug-in hybrid electric vehicle (PHEV) drive systems in Class 2 pick-ups and vans and in Class 6-8 work trucks. The approach for the performance assessment included in-use data, user surveys and laboratory testing; however, few details were given about approach specifics for the past 12-month evaluation period, or for each of the assessment types. The reviewer commented that regarding the Odyne truck design, it sounds as though the truck just runs as a conventional vehicle when the battery has not been charged. The reviewer assumed that this made for a simplified (and perhaps cost-minimized) implementation, but a preferable approach would have been to design the vehicle to achieve hybridization benefits from the electric motor and energy storage system (such as regenerative braking and engine downsizing/load leveling) even when the battery was not fully charged.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer remarked that this demonstration (though expensive) was absolutely necessary for this particular market acceptance. Because over 60% of petroleum is used in commercial vehicles, adaptation of electric propulsion is critical to achieving reductions in petroleum usage.

Reviewer 2:

The reviewer pointed out that for a fleet demonstration with such funding, one would anticipate higher fidelity data from the vehicles to analyze the success and usage in the fleets. This data would include second-by-second fuel use, battery use, velocity, temperature, etc. The reviewer added that most importantly, these data would be analyzed per the technology and drive cycles. The reviewer added that this technical data in the field is critical in understanding the powertrain systems for improvements and advancement.

Reviewer 3:

The reviewer commented as stated above, technologies representative of commercially available systems were deployed and placed in service in multiple duty cycles, and data was gathered with various powertrain calibrations, allowing for continued development during the program.

Reviewer 4:

The reviewer stated that the vehicles have been deployed and data is being transmitted to show effectiveness. The project could include better information on reliability and maintenance issues encountered.

Reviewer 5:

The reviewer reported that the overall accomplishments included deployment of 296 medium-duty PHEVs into 64 different fleets around the country. The presentation included some fuel economy and emissions performance measurements, though these seemed to be measured over repeated, standardized drive cycles rather than from the real-world deployments. The reviewer added that the results that were shown also included some apparent errors. For example, two different baseline conventional vehicle fuel usage numbers for the same driving distance scenario on Slide 11, and a claim of 50% or greater greenhouse gas (GHG) reduction on Slide 12 that seemed to be contradicted by the fuel consumption data on that slide, particularly considering potential GHG emissions from producing the electricity for charging the PHEVs. The presenter also acknowledged that the data was old and in need of updating, indeed two of the plots were unchanged from the 2014 presentation. The reviewer added that it would have been nice to see more quantitative in-use data from the deployed vehicles presented, along with comparisons of the PHEVs to comparable conventional and comparable hybrid electric vehicles (HEV) (i.e., non-plug-in) baseline vehicle variants. The reviewer stated that the presentation included results from a survey of users regarding their observations and satisfaction with the vehicles; however, the survey sample size needs to be larger in order to draw much in the way of definitive conclusions. The presentation did not mention metrics on job creation (another goal of the American Recovery and Reinvestment Act [ARRA] program); the presenter indicated that these would be included in the final report.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer pointed out that the project involved multiple partners and seemed to include a good level of collaboration and coordination.

Reviewer 2:
The reviewer suggested that the project team might have considered broader partnerships beyond VIA and Odyne, perhaps a couple of the Class 8 companies funded in the SuperTruck program.

Reviewer 3:
The reviewer said that the project team had a good partner selection allowing for field-test-capable vehicles (though somewhat delayed for some vehicle types), fleet management, data collection operation and analysis.

Reviewer 4:
The reviewer cited a good team of Electric Power Research Institute (EPRI), South Coast Air Quality Management District (SCAQMD), California Energy Commission (CEC) and numerous fleets to deploy, test and coordinate.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer stated that, although this was an expensive program overall, most results were achieved. The reviewer would have preferred seeing higher-quality data and analysis from the vehicles.

Reviewer 2:
The reviewer stated that the project team briefly discussed the request for more funding to allow for completion of evaluation (data collection) period and final report. For $45 million in DOE funding, it would seem that these two areas are critical and should have been planned for in the project planning

Reviewer 3:
The reviewer commented that due to California Air Resources Board (CARB) delays in certification, the project was said to be delayed but the proposal to obtain additional outside funding to provide additional data is valuable.

Reviewer 4:
The reviewer said that the project did not include a specific future work slide, perhaps because the DOE-supported portion of the project is scheduled to end this summer. It was good to hear that the data collection and analysis will continue at least through the end of the year with the support of SCAQMD funds.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer said that this project directly supports the petroleum reduction mission of DOE as well as deploying advanced technologies into the market.

Reviewer 2:
The reviewer said yes, proven petroleum savings were discussed.

Reviewer 3:
The reviewer commented that fleet demonstration of these vehicles shows petroleum use reduction potential.

Reviewer 4:
The reviewer said yes, the deployed PHEV trucks are expected to displace petroleum. To the extent that the project advances the commercialization potential of PHEV trucks, it could take credit for enabling even larger levels of petroleum displacement. The reviewer added that it would have been nice to see the in-use

displacement and the long-term commercialization potential discussed/quantified in more detail, though it was encouraging to hear the presenter say that the vehicle manufacturers have begun selling to other customers.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer noted that the project is acquiring (?) additional funding from outside sources after the contract ends.

Reviewer 2:

The reviewer said it seems like a large funding amount for vehicles with fairly high technology readiness numbers; the reviewer realized that there were a large number of vehicles deployed, and perhaps there is a difference between ARRA expectations and typical DOE return on investment.

Medium and Heavy-Duty Vehicle Field Evaluations: Ken Kelly (National Renewable Energy Laboratory) - vss001

Presenter

Ken Kelly, National Renewable Energy Laboratory.

Reviewer Sample Size

A total of four reviewers evaluated this project.

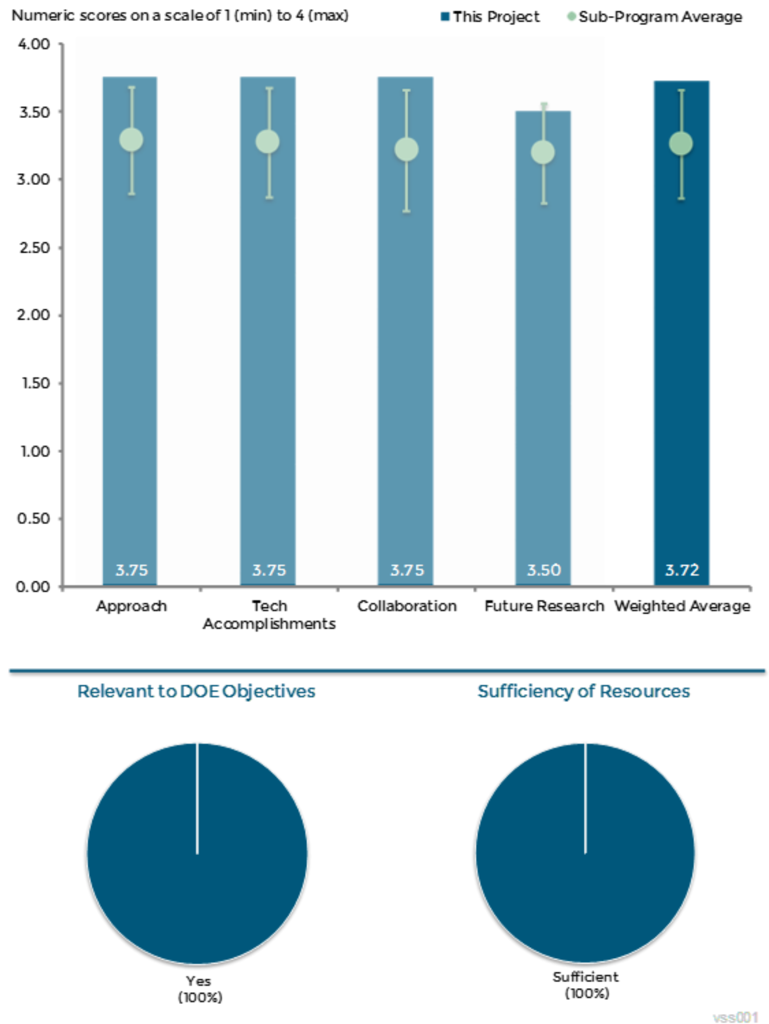


Figure 1-3 Medium and Heavy-Duty Vehicle Field Evaluations: Ken Kelly (National Renewable Energy Laboratory) - Vehicle Systems

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that the approach of the medium- and heavy-duty field testing project has proved to be excellent. The fleet selection and the vehicle and equipment manufacturers in the project have provided very useful data analysis and published reports. The reviewer added that the data collected including drive cycle, operating costs, fuel economy and chassis dynamometer testing has provided an excellent data set to evaluate the fleets.

Reviewer 2:

The reviewer said that the approach is methodical and well laid out. It is unbiased and is able to evaluate the technologies over real-world duty cycles.

Reviewer 3:

The reviewer commented that the excellent utilization of limited resources to both conduct core work and to add in emerging work to complement project objectives.

Reviewer 4:

The reviewer reported that the project addresses the barriers identified by generating unbiased data on technology usage, as well as drawing conclusions regarding the effectiveness of the technologies under real-world conditions. The result of this work is valuable knowledge of the strengths and weaknesses of each technology and their appropriateness in a given application. The reviewer added that this activity can be characterized as a support role, in collecting and interpreting the data. One suggestion would be to take a lead role to advise and engage with partners to define the parameters of the study up front. The reviewer suggested, for example, recommending the most appropriate technology based on the fleet and their operating characteristics. Over time, there should be enough data in Fleet DNA database to make recommendations for future studies.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer commented that technical accomplishments in fiscal year (FY) 2015 have been excellent. Close coordination with DOE including Clean Cities and 21st Century Truck Partnership has helped to get information out to the public about the project. The reviewer added that several new fleet evaluation efforts have been kicked off this year and data collection and reports of ongoing activities have provided technical reports that were published and presented to the industry.

Reviewer 2:

The reviewer noted the excellent selection of fleets and technologies.

Reviewer 3:

The reviewer reported that the achievements have been to plan and present a well-executed program.

Reviewer 4:

The reviewer observed that completing three data collection reports and continuing four others is a sizeable workload for the scope and budget. The reports contain valuable information for understanding potential fuel savings and as a guide for fleets to make informed decisions.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that the collaboration and coordination in this project is outstanding. Without support from the industry partners this project would not be very successful. The reviewer added that the industry partners are absolutely necessary to the success of this project.

Reviewer 2:

The reviewer praised excellent work with Clean Cities and industry organizations to engage fleets.

Reviewer 3:

The reviewer reported that the collaboration is well laid out and results in a well-balanced dataset. The reviewer did not see from the material who the end users were or how the data and analyzed results were actually shared.

Reviewer 4:

The reviewer pointed out that there was an excellent selection of reputable fleet partners to collaborate on the programs. It is not clear how these results feed back to the original equipment manufacturers (OEMs), however, for them to make system improvement.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer commented that continued funding of these efforts to include other fleets and other technologies is highly recommended to support Vehicle Technology Office objectives. The reviewer deemed this work to have provided a great return on investment.

Reviewer 2:
The reviewer stated that the proposed future work will provide additional valuable information to this project. Data from additional fleets as technology advances will help to evaluate new technologies and performing cross-cutting analysis rather than only single-fleet analysis will allow the evaluation of tradeoffs of the technology evaluated against different duty cycles, which will be useful.

Reviewer 3:
The reviewer noted that the proposed next steps make logical sense. The reviewer was disappointed to see that the platooning technology was not included in any significant way. The reviewer thought this technology is one of the most exciting opportunities that requires greater understanding, especially what needs to happen to the following vehicles to increase their efficiency.

Reviewer 4:
The reviewer stated that the program is effective and continues to do good work. The reviewer would like to see this work executed in more of a project format with clear start and end dates, rather than an ongoing activity.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer remarked that the project is very relevant to the DOE objectives. It is necessary to have projects like this one that provide unbiased data and analysis to determine how the advanced technology systems are actually performing in real-world situations.

Reviewer 2:
The reviewer stated that real-world field test of technologies goes beyond the hype and will truly confirm the efficiencies and stated fuel economy (FE) improvements.

Reviewer 3:
The reviewer said yes, data available to fleets provides adoption incentive. Real-world data supports ongoing technology advancement.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer said that the resources in this project appear to be adequate.

DOE's Effort to Improve Heavy Vehicle Fuel Efficiency through Improved Aerodynamics: Kambiz Salari (Lawrence Livermore National Laboratory) - vss006

Presenter

Kambiz Salari, Lawrence Livermore National Laboratory.

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

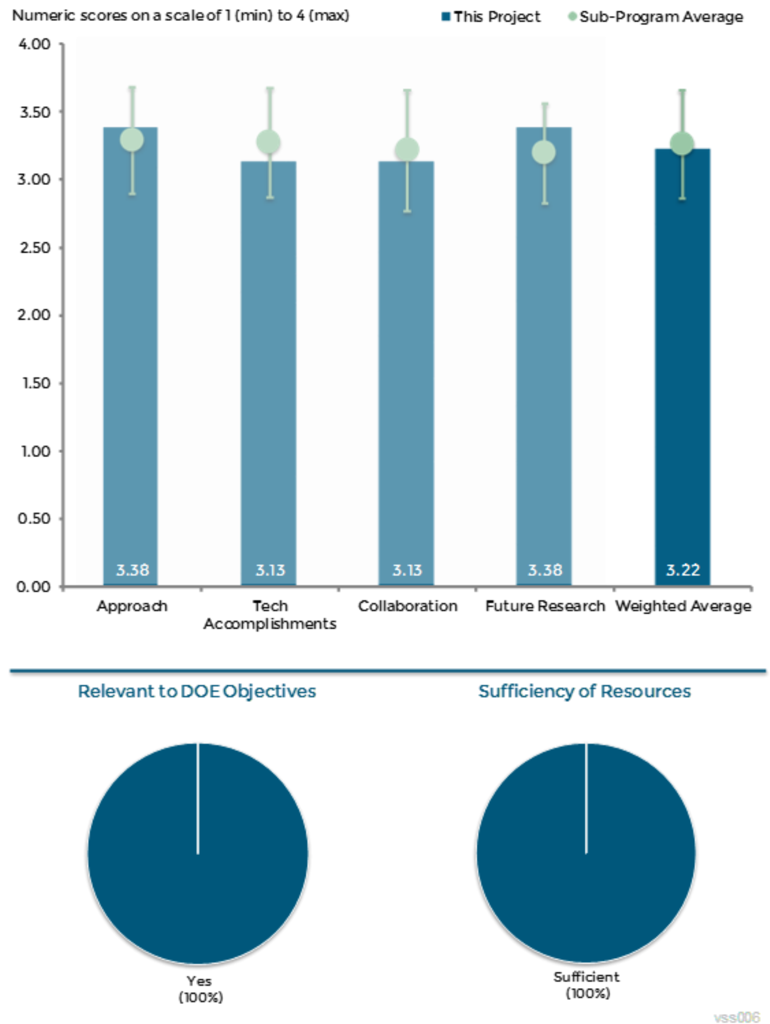


Figure 1-4 DOE's Effort to Improve Heavy Vehicle Fuel Efficiency through Improved Aerodynamics: Kambiz Salari (Lawrence Livermore National Laboratory) - Vehicle Systems

Reviewer 1:

The reviewer stated that this is a well-established and solid approach by the project team, tested and proven over many years of research. The effort to address the tanker sector is interesting, as most research to date has focused on box trailers. The reviewer added that science-based computational work is appropriate to explore the design space. The integrated approach using the generic speed form (GSF) model, despite practical implementation difficulties in the real world, is essential to show what is possible in truck aero drag reduction. (One key benefit of this work is demonstrating the aero drag reduction possibilities with new creative solutions.)

Reviewer 2:

The reviewer reported that this is a very important topic and is excited that DOE continues to fund this area of research and testing. Reviewing the materials, the reviewer was somewhat concerned that there is not as much collaboration with the industry. This project is not discussed in the industry as much as the reviewer would expect or desire. The reviewer added that the approach of comparing results from computational fluid dynamics (CFD), various wind tunnels, along with some field testing, is crucial to understanding the performance and in getting buy-in from the industry on real-world results of these devices. The reviewer pointed out the team is looking at developments and testing them. For example, analyzing vented side skirts, which was only really shown this past March at the Mid-American Trucking Show in Louisville and this team has already assessed them. The reviewer praised this as well done.

Reviewer 3:

The reviewer commented that the project rightly focuses on aerodynamic drag of Class 7-8 tractor-trailers, which is a significant contributor to fuel consumption. The emphasis on tanker trailers is questionable, given the relatively small population of tankers compared to dry van trailers.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer stated that there has been a great deal of skepticism of these devices, so this data is very important to adoption and savings in real-world fuel use. It seemed to the reviewer that more progress could be made, given what was presented.

Reviewer 2:

The reviewer commented that the work is addressing the overarching barrier of aerodynamic drag; however, the work does not appear to include technical implementation barriers, such as the impact of the larger trailer skirts and underbody panel on the tractor. There are operational barriers to low-ground-clearance skirts that need to be addressed. The reviewer added that weight, durability and heat in the engine compartment make the underbody panel challenging to implement. Closer work with tractor and trailer partners would assist in identifying these issue and in providing workable solutions.

Reviewer 3:

The reviewer commented that the team has already been successful in helping bring practical and effective aerodynamic devices to the market overall, saying this is a very significant accomplishment to feed Vehicle Technologies Office (VTO) goals. This work has helped make this real-world implementation possible. The reviewer added that it was good to highlight fuel economy reduction by use of rough skinned shipping containers as an aside in the presentation, it will be interesting to see if Lawrence Livermore National Laboratory (LLNL) can come up with a creative solution here. The GSF1's ability to reduce drag at higher yaw angles could have benefits in the real world, as most trucks experience some yaw in regular operation (no truck is ever in a no-crosswind situation). The reviewer also said tanker trailer drag reduction concepts are quite interesting, particularly the centerline or side skirts that are similar to those used in box trailers. The ideas presented will not involve major redesign of existing tankers (which would make fleets uncomfortable because of cost and operational considerations). The reviewer added that it is very good for the team to look at the aero effects of platooning, this appears to be an area for improvement, as there are tradeoffs associated with platooning (balance of increased efficiency from close spacing but compromises in truck performance if spacing is too close). Collaboration with the National Renewable Energy Laboratory (NREL), who is working on the platooning effort, is important.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer commented that the team has a good list of partners, including OEMs, trailer manufacturers, and aero device manufacturers. The team has worked with a selection of fleets as well, which is very important for future commercialization and acceptance. The reviewer added that the collaboration with NREL on the platooning project is of particular interest, and will add to the knowledge base of this emerging technology.

Reviewer 2:

The reviewer would have liked to see more evidence of exact interactions from the industry and government. The reviewer asked what the team/program is learning from the field to help make this project even more successful. Strong team, though, and if they are engaged, this is less of an issue. This team too often criticizes industry for not adopting these devices, but this program is not set up to understand deeply all the benefits and consequences of each concept. The reviewer added that this focuses mostly on the FE performance. Kambiz did a great job this year defining the team's place in looking at out-of-the-box concepts to pull the topic for discussion, which is quite helpful.

Reviewer 3:

The reviewer reported that direct collaboration with trailer manufacturers was not evident in the presentation, which is necessary to translate results into production.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer commented that the future research is a continuation of excellent work. Underbody treatments and integration potentials for tractors and trailers will be good to explore further, and will support other DOE efforts such as SuperTruck.

Reviewer 2:

The reviewer reported that it is good to complete this work. The reviewer was not sure much effort should be continued on tankers, as the weight penalty of adding devices and lack of payload hauling affect the net benefit. Tankers leaving their dock 100% loaded at 80,000 pounds (lb.) are at the legal limit. Adding 500 lb. for aerodynamic devices and lowering the material hauled by the same amount is very costly to the fleet and not a good economic decision. Also, the reviewer said tankers have a 20-year life, and as they are so expensive (10 times that of dry vans), it is best to stay focused on dry vans and reefers. The reviewer strongly supports the efforts on trailer aerodynamics and platooning. This can critically help the future of platooning, a rather simple, high fuel-saving concept.

Reviewer 3:

The reviewer commented that GSF1 development is intriguing, and would like to see the shape evolve into a truck in the future, by including grille opening for the cooling system, tractor-trailer gap and ground clearance. The reviewer recommended keeping the focus on the dry van box trailer as opposed to tankers, with respect to the potential impact dry van trailers would make, given their much larger population in service.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that aerodynamics are important for us to understand to improve mpg on tractor trailers.

Reviewer 2:

The reviewer commented that the project has actually demonstrated petroleum displacement, as the work has already resulted in deployment of aero devices to displace petroleum. The reviewer added that aero drag reduction on trucks is a very important petroleum displacement opportunity.

Reviewer 3:

The reviewer said yes, tractor-trailer aero is a key lever for further fuel consumption reduction.

Reviewer 4:

The reviewer said that we need more suppliers in this space and this work can help pull in new manufacturers and innovation. We are just starting to see this on next-generation skirts and rear tails. The reviewer added that this work may already be pulling in new ideas.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer indicated that the resources appear to be sufficient for the work being performed; the team is making good use of the funding they receive.

Reviewer 2:

The reviewer stated that funding is sufficient for the importance of the topic

Reviewer 3:

The reviewer was a bit concerned about depth of the work.

Idaho National Laboratory Testing of Advanced Technology Vehicles: Matthew Shirk (Idaho National Laboratory) - vss021

Presenter

Matthew Shirk, Idaho National Laboratory.

Reviewer Sample Size

A total of four reviewers evaluated this project.

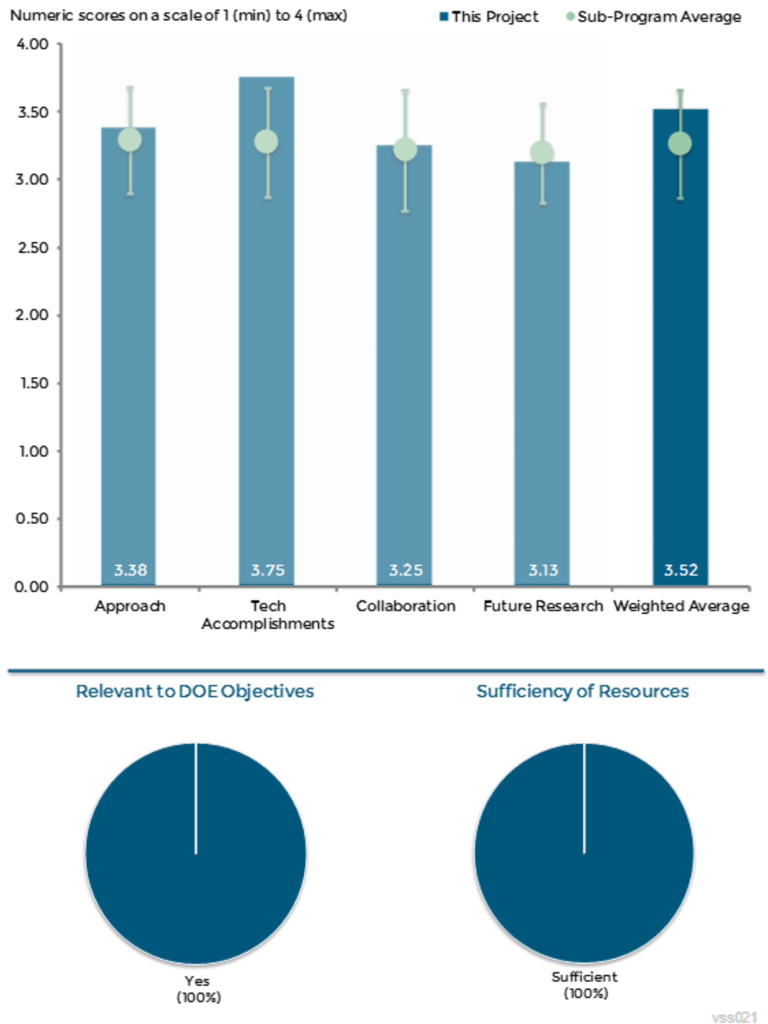


Figure 1-5 Idaho National Laboratory Testing of Advanced Technology Vehicles: Matthew Shirk (Idaho National Laboratory) - Vehicle Systems

Question 1: Approach to performing the work–the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that this program correctly encompasses the necessary evaluation of real-world field data that is fundamentally needed to validate development models from the OEMs and provide data to consumers for increased adoption of this technology. The reviewer also said the project might consider (or has considered) a broader regional control to get added field data by geographical and environmental controls.

Reviewer 2:

The reviewer thought this type of inexpensive, real-world verification of technologies is a good additional validation of bench tests. It is so important to understand the performance of technologies during general operation “out in the wild.” One to two million dollars for all these models is a relatively low amount of money.

Reviewer 3:

The reviewer commented that the objectives and scope in the beginning should have pointed out that this study was limited to passenger cars. The reason for including internal combustion engine passenger vehicles was never made clear. The reviewer thought a very poor aspect of the approach was not controlling for the drive cycle. Drive cycle is a significant, if not critical, influence on energy consumption.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer commented that with some additional iterations, this program is very necessary to validate both developmental assumptions (modeling) and customer information.

Reviewer 2:

The reviewer reported that the project team is on track to plans and reporting conditions of operation to compare to the more standardized bench and track testing. The reviewer added that the project team had a pretty comprehensive set of tests and published quarterly. The reviewer also said it is nice that a common project is testing batteries/components as well as conducting track and real-world testing. The project supports commonality in approach and reporting to help consumers and OEMs.

Reviewer 3:

The reviewer expressed no issues with the technical accomplishments.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer observed that it was a truly outstanding effort to bring in six major OEMs and other national laboratories on a collaborative effort. Other programs, simulation model development, could benefit from this example.

Reviewer 2:

The reviewer reported always having wondered if the stakeholders of these programs are truly gaining the benefit of this data collection and taking full advantage of the opportunity. OEMs in particular already have the cars released and in production, so sometimes they do not want to hear this information, as it may require improvement efforts, etc.

Reviewer 3:

The reviewer had no issues with collaboration and coordination. The reviewer could not suggest any improvements here.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer had no comments on proposed future research other than that drive cycles should be controlled for in future research.

Reviewer 2:

The reviewer stated that finishing the scope and digging deeper into stakeholder questions will help.

Reviewer 3:

The reviewer reiterated that the project team might consider (or has considered) a broader regional control to get added field data on geographical and environmental controls.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer commented that this project supports DOE's goal of petroleum reduction and energy security. The comparison of data on electric vehicles (EVs) with internal combustion engine (ICE) vehicles is meaningful.

Reviewer 2:

The reviewer stated that it is crucial to follow development into deployment and ensure that the products/technologies are delivering and can help with the next round of design generation.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

There were no reviewer comments on resources.

Advanced Vehicle Testing and Evaluation: Richard Jacobson (Intertek) - vss029

Presenter

Jeremy Diez, Intertek.

Reviewer Sample Size

A total of five reviewers evaluated this project.

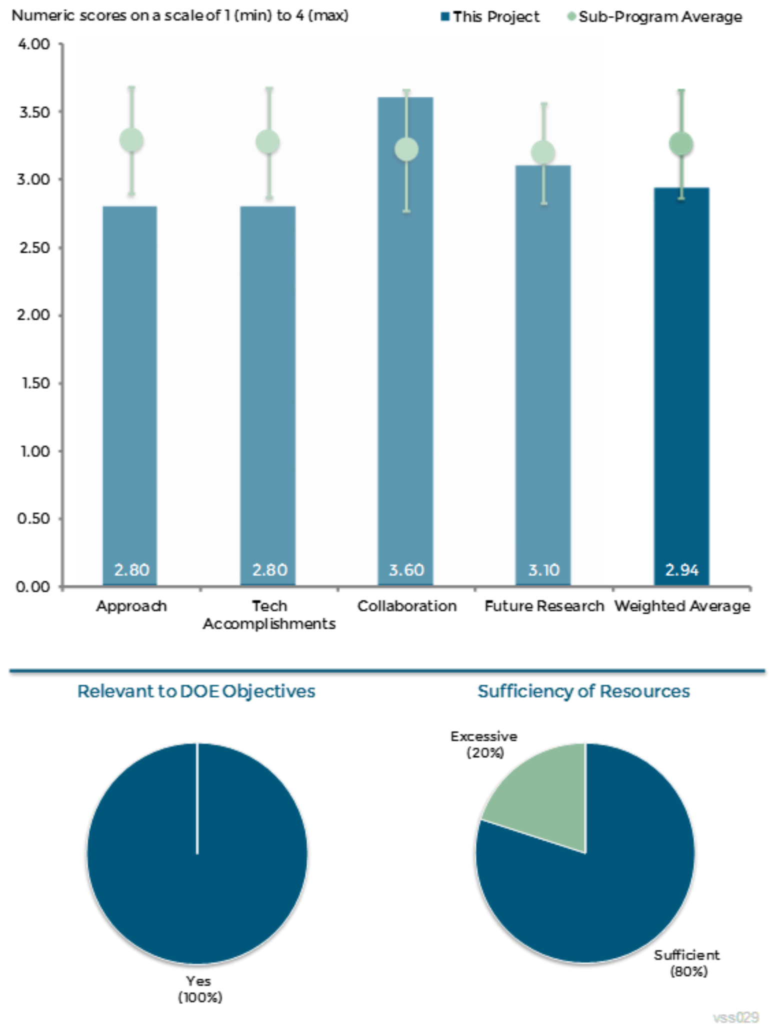


Figure 1-6 Advanced Vehicle Testing and Evaluation: Richard Jacobson (Intertek) - Vehicle Systems

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The Advanced Vehicle Testing & Evaluation (AVTE) project is very well designed and provides a thorough assessment of the vehicles selected. Some additional information on the drive cycles and their repeatability would be helpful to understand how to interpret the results. Also, the reviewer said, showing comparable data from conventional vehicles operating under the same conditions would help give a good relative comparison.

Reviewer 2:

The reviewer listed the strengths of the approach, which include monitoring a small number of each vehicle type over a long period of time and many miles of driving; collecting data on vehicle/component efficiency; and performance over the testing period. The reviewer also enumerated the weaknesses, which include questionable representativeness of the partner fleet operating profiles relative to typical operation of the vehicles in the hands of consumers (admittedly an inherent limitation of deploying them into applications that will quickly accumulate a lot of operating miles); narrow climate representativeness - most of the vehicles seemed to be deployed in Phoenix, which represents a climate on one end of the spectrum. This was acknowledged as a reviewer comment from 2014 that the team will try to address as part of future work, but appeared still not have been addressed. Minimal baseline vehicle data collection and accessibility, data collection and reporting on baseline vehicles (representative of comparable conventional counterparts to the tested vehicles and/or of the best-selling vehicles on the market) would be one way to control for the potential representativeness issues of the drive cycles and climates in the selected fleets, and would provide valuable on-road data in its own right for those vehicles currently dominating the light-duty market. The reviewer said that in response to a question at the end of the presentation, the presenter mentioned that baseline data is sometimes collected from comparable conventional vehicles when they exist; however, this did not sound like it happens all (or even most) of the time, and after looking at posted results for several HEVs and EVs at the provided website (avt.inl.gov), there did not seem to be any baseline conventional vehicle information available.

Reviewer 3:

The reviewer commented that the objective of the project is to provide on-road test data from advanced vehicles to Idaho National Laboratory (INL) for later analysis. The approach is based on purchasing and instrumenting vehicles, which are then loaned to fleets after baseline testing. The reviewer added that because acquiring new vehicles can be more difficult in some states compared to others, it is good that Intertek is now involved, with an office in California. In addition to instrumenting the vehicle and providing data, Intertek mentioned that numerous test procedures were developed (battery, component durability, vehicle testing, etc.). The reviewer also said that this effort appears to be a duplication of existing industry procedures. If Intertek does leverage these industry procedures, then modifications should be minimal and require minimum effort. A lot of the information collected prior to vehicle testing is available publicly. For example, vehicle specifications, performance, etc. can be quickly found online. Regarding baseline testing, if the tests need to be performed, a comparison should be provided with published values (e.g., performance from Car & Driver Magazine). Collecting on-road vehicle energy consumption and cost is important, especially if all the data is made publicly available. Currently, it appears that only aggregated test data is available. The reviewer recommended considering sharing additional information through a database. Because one of the main objective is to produce lifecycle fuel economy and cost, some of the testing should be done outside of fleet, which is well known for having much different drivers' behaviors and driving cycles than usual drivers. Without at least a comparison, the results from the on-road data cannot and should not be generalized outside of fleet drivers.

Reviewer 4:

The reviewer stated that the project team established procedures, data collection and publication procedure, allowing information to be shared with the public. The reviewer questioned the coast-down data accumulation, noting that the amount of effort required seemed high.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer commented that while good progress has been made, some additional work to evaluate medium- and heavy-duty MD/HD vehicles should be included.

Reviewer 2:

The reviewer commented that the project accomplishments include acquiring and placing over 90 vehicles representing a range of advanced technologies in fleets, and collecting over 4 million miles of data during fleet testing. Some of the approach limitations (with respect to representativeness of the vehicle operating profiles, climates and accompanying baseline vehicle data) translate to limitations for the accomplishments. The reviewer added that summary results on the collected data are posted on the avt.inl.gov website. Because these data seem to be collected without manufacturer participation (or non-disclosure agreements) it would be nice to also have micro data (such as a representative weeks' worth of data for each vehicle) publicly available as well per the Argonne National Laboratory (ANL) D3 data availability model. Though perhaps this would be an INL rather than an Intertek activity.

Reviewer 3:

The reviewer stated that public information does not include all available use data, only a summary sheet. The reviewer asked if there is a mechanism that would allow full drive cycle and vehicle related information to be available to the public.

Reviewer 4:

The reviewer stated that the first section of the accomplishment lists the 2013 test data summary from the 2013 Ford Fusion (Slide 8). All this data, and more, can be found online. While it is helpful to have them in a single location, the reviewer was unsure why this is listed as an accomplishment. The second section of the accomplishment provides on-road fuel economy measurement (Slide 9). The reviewer asked how these values compare to those from other websites and sources. More and more real-world fuel economy data is becoming available from a wide range of vehicle technologies. The reviewer recommends that Intertek highlight how their project is different and/or complements data provided by drivers.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer remarked that collaboration with other institution is very well defined, with distinct roles and responsibilities.

Reviewer 2:

The reviewer commented that the collaboration and data has multiple partners and is well coordinated.

Reviewer 3:

The reviewer commented that the project demonstrates a large degree of collaboration and coordination with other institutions. The strongest collaborations seem to be the following: work with fleets where the vehicles are placed in service and obtaining fueling log data from the fleets, in which the reviewer asked whether the fleets are also relied on to report kWh charged for electrified vehicles from charging equipment that reports this data like a fuel sale; and work with INL on procedure development and to store, analyze, and produce summary reports on the data; The reviewer also stated that additional collaborations include the following: collaboration with ANL on additional test procedure development and chassis dynamometer testing, though the extent of ANL's interaction with Intertek versus INL was unclear; collaboration with NREL on MD/HD vehicle conversions, though this seemed to be more of a future work activity because limited information was given; and collaboration with the Society of Automotive Engineers (SAE) on the interoperability testing, though this testing was the focus of a different project review (i.e., vss169).

Reviewer 4:

The reviewer stated that there is a good mix of collaborators, but the project team needs to determine additional mileage accumulation partners and look for other temperature extremes, not just Phoenix high temperatures.

Reviewer 5:

The reviewer said that vehicle OEMs, electric vehicle supply equipment (EVSE) manufacturers and other labs have been engaged. Partner fleets (EZ Messenger and Total Transit) could be expanded with more fleets and/or locations. Industry access to data could be improved, but INL analysis of the data is helpful and shown in separate presentation/review.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer pointed out that plans for future work addresses concerns noted above. Future work to further the establishment of new test protocols has significant value.

Reviewer 2:

The reviewer stated that the proposed future work includes continuous improvements on test methods, procedures and reporting approaches, expansion of fleet operators to help address current representativeness issues with operating profiles and climates, and expansion of scope to include MD/HD vehicles, which currently seems to be lacking. The presentation also highlighted ongoing testing plans as additional future work, to include completion of multi-year testing for the currently-deployed vehicles and initiation of testing on new, advanced vehicle technologies, which is valuable to continue adding to the body of knowledge being generated by the project. The reviewer stated that these future work plans are valuable for the reasons indicated. Additional future work should consider including more baseline conventional vehicle testing representative of mainstream vehicles on the market to compare against the advanced-technology vehicle performance, not to mention the intrinsic value of such detailed field data on vehicles dominating the current market that would not otherwise be broadly available for researcher use.

Reviewer 3:

The reviewer said there needs to be a consideration in the vehicle selection process for projected vehicle mix in the consumer fleet, as well as possible considerations for MD vehicle mileage accumulation.

Reviewer 4:

The reviewer observed that most of the future challenges and technical barriers (Slide 13) are related to charging rather than vehicles. As a result, the reviewer asked if the objectives of the program be revisited to address these barriers. In addition, future research appears to be focused on doing the same thing with improved process rather than on how the project could evolve to answer additional questions. Because questions are currently evolving, one would expect that the type of testing performed or data collected would evolve as well, which does not appear to be the case.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer said that the project obtains field test data on advanced technology vehicle performance that would not otherwise be available and provides a sanity check on the in-use performance of these vehicles.

Reviewer 2:

The reviewer commented that these datasets made public have high value as they are generally not available and have a number of customers from OEMs, national laboratories, universities, and other technical suppliers.

Reviewer 3:

The reviewer said that independently gathered vehicle use and performance data is critical for consumers planning on making the investment into advanced vehicle technologies.

Reviewer 4:

The reviewer pointed out that the project provides on-road test data for advanced vehicles for fleets

Reviewer 5:

The reviewer said yes, acquiring data to help understand and develop electric drive and new advanced technologies is key to reducing petroleum displacement.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that the resources seem adequate for the work described. It might be a useful exercise to inventory the performance changes seen over time from past vehicle testing, and to assess the value and applicability of lessons learned when performance degradation has been observed, in order to confirm the appropriateness of the testing intervals and durations currently used.

Reviewer 2:

The reviewer said that with the advance of technologies, the reviewer would expect the cost of vehicle instrumentation and data collection to significantly decrease. The current budget of $6 million (Slide 2) for 50 vehicles (Slide 15) seems very high. If vehicle energy consumption is one of the key parameters, the reviewer asked if data could be collected on a larger number of vehicles for much smaller funding through simple on-board diagnostic (OBD) instrumentation.

Advanced Technology Vehicle Lab Benchmarking (L1 and L2): Kevin Stutenberg (Argonne National Laboratory) - vss030

Presenter

Kevin Stutenberg, Argonne National Laboratory.

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

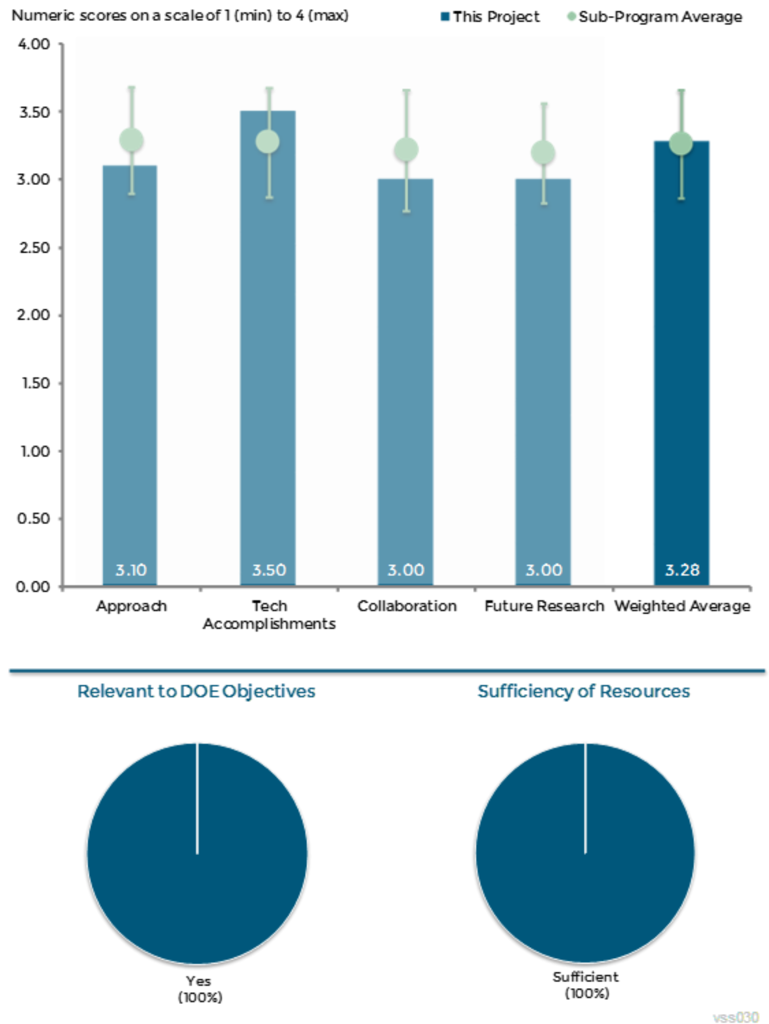


Figure 1-7 Advanced Technology Vehicle Lab Benchmarking (L1 and L2): Kevin Stutenberg (Argonne National Laboratory) - Vehicle Systems

Reviewer 1:

The reviewer commented that testing is comprehensive and in-depth and the reporting is also excellent.

Reviewer 2:

The reviewer asked if the benchmarking test and measurement approach use a standard testing methodology based on approved industry standards. This needs to be stated up front.

Reviewer 3:

The reviewer reported that the Advanced Technology Vehicle Lab Benchmarking, Level 1 and 2 is a long and well- established project. The approach to the testing activities has been refined in a variety of ways over the years. The reviewer added that this includes continually improving testing methods, instrumentation, equipment, analysis procedures, and so forth. At this point, it has probably become more difficult to continue and refine the process, although there are likely still areas that can be made more cost effective, such as the improved instrumentation techniques alluded to this year. In this context, the reviewer said that, as a mature project with the continuing requirement to prove value and reduce costs, it may be beneficial to conduct a blank-sheet exercise looking at the scope of the whole project from a fresh perspective, in this case questioning long-standing assumptions, scope, processes, and procedures. The reviewer stated that it is quite possible little may come of such an exercise, but it is feasible that a new scope, approaches, cost reduction opportunities, streamlining mechanisms, data dissemination strategies, and/or customers, may be identified or enhanced to further increase the overall value proposition of the project.

Reviewer 4:

The reviewer stated that the selection of which vehicles undergo Level 1 testing and which vehicles undergo Level 2 testing seems arbitrary. There needs to be standard operating procedure or protocol.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:
The reviewer commented that there was excellent throughput in terms of testing and reporting results and the reports were well done. The value of the program is in providing independent, timely, high-quality (accurate) test results.

Reviewer 2:
The reviewer stated that this year the project has been looking at a variety of vehicles including battery electric vehicles (BEVs), range-extended BEVs, PHEVs, diesels, and compressed natural gas (CNG) conversions. There have been a number of accomplishments including revised instrumentation methods, evaluation of idle stop/natural gas vehicles (NGVs), EV energy consumption versus ambient temperature, understanding variations in BEV range, in-depth blended PHEV evaluation, and aggressive thermal usage assessment. The reviewer added that the revised instrumentation methods have aided in streamlining the data acquisition process and cost control, while idle stop impacts for CNG operation have been quantified. Interestingly, for aggressive cycles, the negative energy impact of air conditioning (A/C) is largely mitigated by other factors including improved losses and heating, ventilating, and air conditioning (HVAC) is not the only contributor to high EV energy consumption under cold operating conditions. The reviewer stated that overall, a respectable list of accomplishments across a wide variety of areas was evident.

Reviewer 3:
The reviewer noted that it would be good to show the comparison between what the OEMs had published with their test results.

Reviewer 4:
The reviewer has no issues with technical accomplishments.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer pointed out that there was excellent collaboration with regulatory and industry partners. The project produces timely, high-quality results.

Reviewer 2:
The reviewer commented that the project has an extensive list of institutions with which it collaborates and coordinates in the government, industry, standards definition organizations (SDO), and international arenas, and although not specifically mentioned, academia as well. There are no obvious gaps in partner collaboration or coordination, but it is important to be continually probing existing partners and considering new ones whether for input on testing activities or as potential new end users of the data.

Reviewer 3:
The reviewer said that closer collaborations with OEMs would be useful to share dyno data; this would provide a better comparison of the benchmarking.

Reviewer 4:
The reviewer noted that the U.S. Environmental Protection Agency (EPA) has not been included. This is a significant omission. The reviewer added that comparisons with EPA data should have been shown and discussed wherever possible. Another reviewer last year made the same comment about making EPA a formal partner on this project, and the reviewer does not understand why such a partnership has not been pursued. The reviewer finds this to be inexcusable.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer commented that the program continues to make good progress with appropriate future choices for testing properties.

Reviewer 2:
The reviewer stated that the authors need to come up with a systematic methodology for selecting which vehicles under Level 1 or Level 2 testing. Second, the objectives of assisting in codes and standards development was stated; however, no results were presented on the impact of this project on SAE J1711 and J1634.

Reviewer 3:
The reviewer stated that the Advanced Technology Vehicle Lab Benchmarking Level 1 and 2 project goes through a screening process with industry and government to identify the most appropriate vehicles to test (whether Level 1 or 2). A key driver is often the uniqueness of a particular technology and how well it fits into the overall testing portfolio, as well of course as vehicle availability. The reviewer added that the projected upcoming Advanced Vehicle Testing Activity (AVTA) vehicles to be tested include a wide range of BEVs, HEV, a bi-fuel CNG, and a range-extended EV, with the emphasis continuing on BEVs. This provides a good cross section of the current vehicular state-of-the-art.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer pointed out that this project supports DOE objectives of petroleum displacement by benchmarking state-of-the-art vehicles; providing independent and public data for evaluation of emerging technologies; and supporting model creation and validation, standards development, and DOE target setting. In short, the Level 1 and 2 benchmarking helps accelerate the evaluation of advanced vehicles and technologies, facilitates and guides research and development, and helps promote adoption of advanced vehicular technologies.

Reviewer 2:
The reviewer stated that this is a useful, independent, public source for technology assessment/evaluation.

Reviewer 3:
The reviewer said that there is no doubt that this project produces and disseminates data useful to DOE for analyzing petroleum displacement and energy efficiency.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer suggested more resources for analysis.

Reviewer 2:
The reviewer stated that resources are sufficient for this project.

Reviewer 3:
The reviewer had no basis to contest the level of funding on this project.

Development of High Power Density Driveline for Vehicles: Oyelayo Ajayi (Argonne National Laboratory) - vss058

Presenter

Oyelayo Ajayi, Argonne National Laboratory.

Reviewer Sample Size

A total of three reviewers evaluated this project.

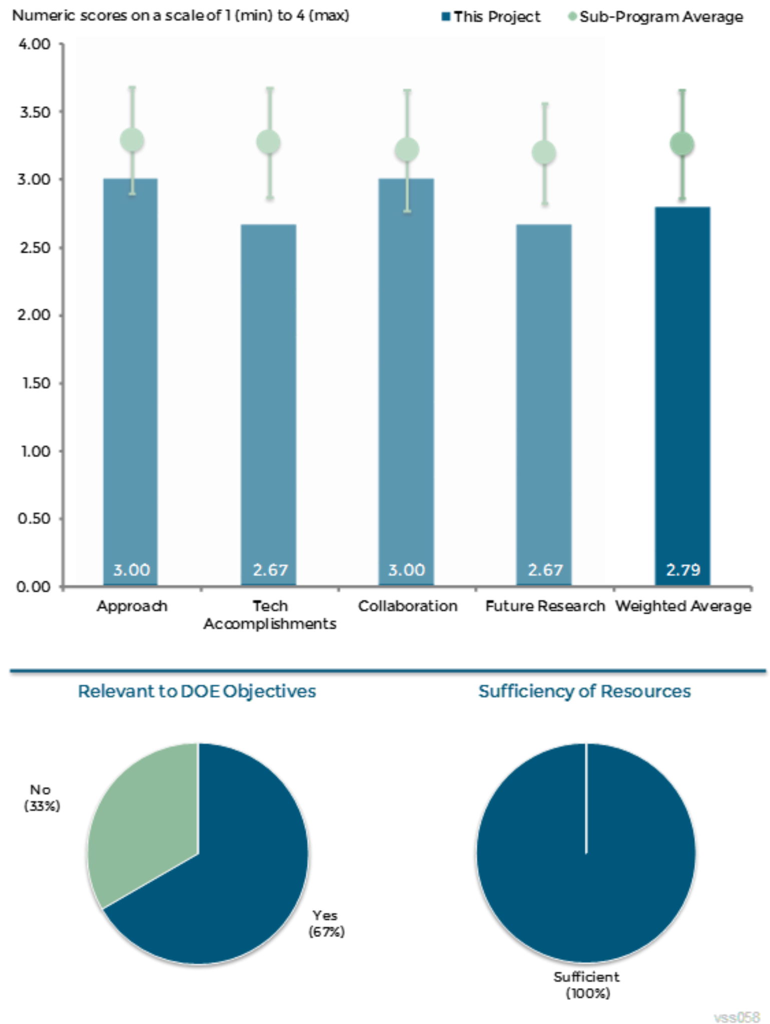


Figure 1-8 Development of High Power Density Driveline for Vehicles: Oyelayo Ajayi (Argonne National Laboratory) - Vehicle Systems

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that while the intent of this project is excellent, the results indicate that there was a mismatch between approach and resources available. In particular, one of the three investigation paths was more time-intensive than anticipated by the project planners.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer stated that the achievement of this project is relatively weak.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer commented that the project involves partnerships with several commercial companies that could potentially help transition technology advancements into the market.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer reported that this project is ending this year, so there is no future work proposed.

Reviewer 2:

The reviewer indicated that the project has ended.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer observed that the project tried to develop mechanisms required for high-density drive lines. High density drive lines are an enabler of improved vehicle fuel efficiency.

Reviewer 2:

The reviewer said that this research supports the overall DOE objectives, but in an area with relatively low potential to succeed.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer noted that the project investigators discovered that the resource allocations were insufficient to perform the full matrix of experiments necessary to complete the planned investigations within the project schedule. As a result, one of the three technology investigation areas was incomplete at the end of the project. The assigned assessment that the resources are sufficient is because the project ends in FY 2015 and additional resources would not affect the project outcome.

SuperTruck - Development and Demonstration of a Fuel-Efficient Class 8 Tractor and Trailer: Russ Zukouski (Navistar International Corporation) - vss064

Presenter

Russ Zukouski, Navistar International Corporation.

Reviewer Sample Size

A total of four reviewers evaluated this project.

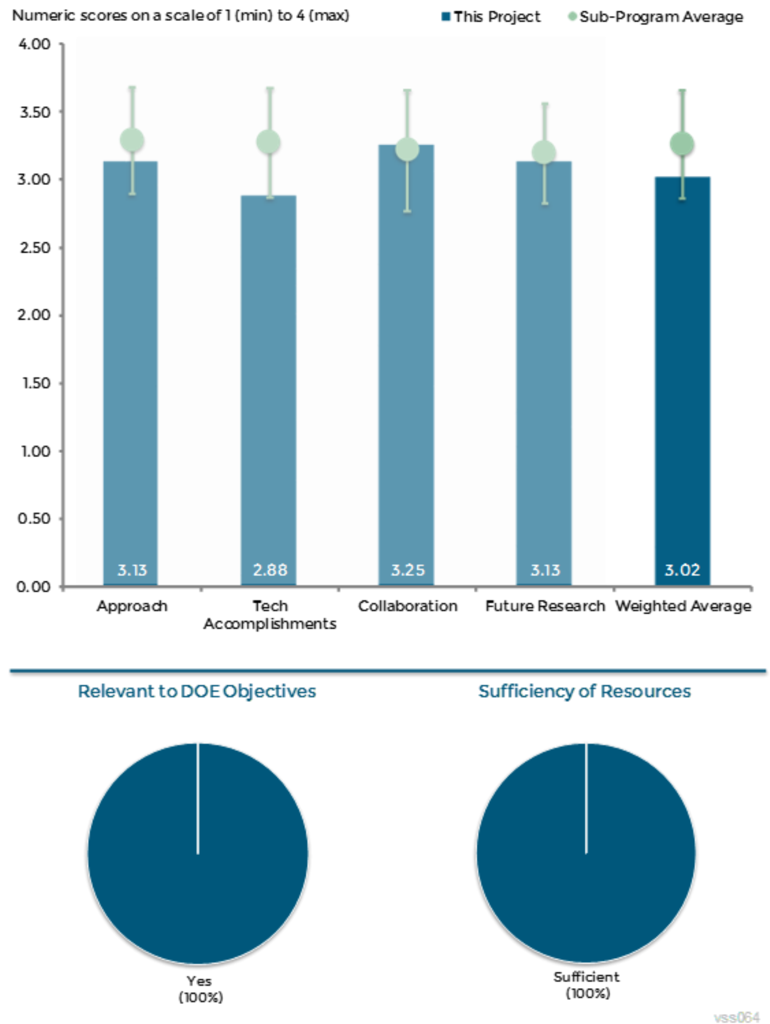


Figure 1-9 SuperTruck - Development and Demonstration of a Fuel-Efficient Class 8 Tractor and Trailer: Russ Zukouski (Navistar International Corporation) -Vehicle Systems

Question 1: Approach to performing the work–the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer liked seeing a standardized way to show fuel economy percentage by individual contributor. The reviewer understood the pause period and the change in strategy on hybridization. The reviewer was unsure of the approach to understanding the contribution of various concepts to their prediction during the next phase of testing, either via bench tests, specific vehicle tests before the full demonstrator exists. Also, the reviewer did not understand how the collaborators are working with the Navistar team.

Reviewer 2:

The reviewer stated that the presentation does not indicate consideration of roadway condition, for example, the International Roughness Index (IRI), which should have a significant influence on achieving objectives. The reviewer added that consideration of the impact of double trailers should be included, as these have potential freight capacity benefits, but it is uncertain how they impact efficiency.

Reviewer 3:

The reviewer commented that the approach includes all needs that can help the program to achieve the program goals; however, waste heat recovery (WHR) via Rankine cycle is not part of plan for the 50% goal.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer believed good progress is being made toward completion, but found little evidence in this presentation (e.g., concern over approach to definitively understanding the percentage contributions of each action). The reviewer expected more detail on cab redesign decision making, light-weighting, and even the hybrid decision. The project team only briefly shared the decision which caused the reviewer to question the depth of analysis in these areas. Another example is the decision to go to 48 volts for idle reduction A/C and hotel loads. This was a decision reached by Navistar and not any of the other SuperTruck teams, the reviewer thought. Some detail on that decision would be helpful and the reviewer thought should have been shared.

Reviewer 2:

The reviewer pointed out that only Slide 16 shows the accomplishments with no tangible improvement since the program resumed in 2014. It seems that there is very little development at a vehicle level.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer said collaboration seems good, but saw little evidence that led the reviewer to feel confident that there is as much joint learning, both ways between the team and collaborators.

Reviewer 2:

The reviewer observed that the presentation does not indicate interaction or partnering with U.S. Department of Transportation (DOT)/Federal Highway Administration (FHWA)/Federal Motor Carrier Safety Administration (FMCSA). This type of partnership may prove beneficial to the project, especially in light of the forthcoming Comprehensive Truck Size and Weight study mandated by Congress in MAP-21.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that the future work is comprehensive with a detailed technology road map toward the goal.

Reviewer 2:

The reviewer reported that there was not much detail on the next phase of the effort **-** prototype and validation. When the first two teams were at this stage about a year ago, they both shared much more detail on their plans. The reviewer does not have the confidence that this team will learn as much without understanding the plan to review/understand the performance of the vehicle.

Reviewer 3:

The reviewer commented that the project should consider the impact of albedo on surfaces as well as potential for incorporation of photovoltaics on the surfaces to assist with power demands

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer said significant MPG improvements

Reviewer 2:

The reviewer indicated that heavy tractor-trailer fuel efficiency is our single biggest opportunity in transportation.

Reviewer 3:

The reviewer pointed out that this not only supports DOT objectives, but also the DOT Clean Transportation Sector Initiative goals of 80% GHG emissions reductions by 2050, as well as EPA objectives.

Reviewer 4:

The reviewer said yes, this project will support the overall DOE objectives of petroleum displacement if Navistar can deliver what they are supposed to deliver in meeting the program goals.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said resources seem sufficient, but with lack of plans, was not sure.

CoolCab Test and Evaluation and CoolCalc HVAC Tool Development: Jason Lustbader (National Renewable Energy Laboratory) - vss075

Presenter

Jason Lustbader, National Renewable Energy Laboratory.

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

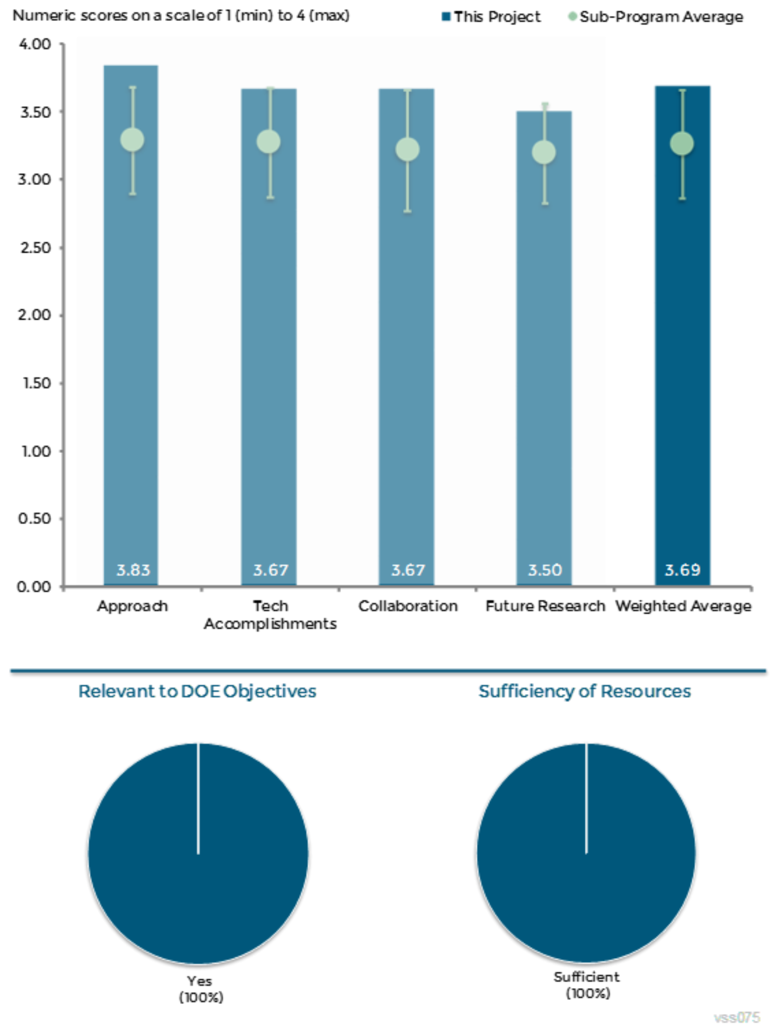


Figure 1-10 CoolCab Test and Evaluation and CoolCalc HVAC Tool Development: Jason Lustbader (National Renewable Energy Laboratory) - Vehicle Systems

Reviewer 1:

The reviewer stated that the project is well designed. The milestones are distinct and easy to understand. The project progression is very orderly. The reviewer added that the mirror image between the technology development and the analytical tool development is an important breakthrough. Too many tech development projects either develop the analytical tool after the technology development or do not develop one at all.

Reviewer 2:

The reviewer stated that the approach appears to address all the sources of heat that influence the temperature in a sleeper cab. The model development will be a useful tool in future sleeper cab design activities. The reviewer would be interested to see if this approach could be applied to day cabs as well.

Reviewer 3:

The reviewer commented that this project is really engaging stakeholders and is focused on an important area of idling and not distracted by other areas. The reviewer added that the project team understands the end users well. The team appreciates the marketplace well but the reviewer would encourage a two-year versus three-year payback. Used good drive cycles for battery charging assumptions. The reviewer suggested developing a fuel cost per battery charge, a key calculation. It helps to review both of these programs at the same time.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer indicated that this project is projected to exceed the overall goals. More test data would increase the confidence in the results. The reviewer added that beyond a reduction in fuel use, an improvement in passenger comfort could be expected as well. If the new technologies become mainstream, the reviewer doubted the cost delta will be that great, at which point the discussion about payback period will become moot. Overall, a great methodical march toward obtaining a couple percentage point reduction in fuel consumption.

Reviewer 2:

The reviewer commented that the accomplishments on insulation, paint and shades are good but the reviewer would like to see more focus on zoned or targeted cooling areas as well.

Reviewer 3:

The reviewer reported that meeting deliverables and metrics, here at the end of the project. Testing and modeling with the same people at the same time helps with expertise and meeting the goals of the project. The reviewer added that lowering heat loads in the summer as you look at the solutions. The project is efficient, and the project team upgraded modeling tools. The reviewer then stated insulation, paint, curtains and shades. 35.7% versus 30% goal for best cab combination. The reviewer also said curtains are a real key part of the solution it seems.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer said that this team/project appears to have excellent collaboration with industry partners. Companies talk about this project outside of the DOE and this review annually.

Reviewer 2:

The reviewer stated that the collaboration is good. The reviewer would like to see more Tier 1 suppliers involved. The OEMs are clearly the main lead here, but the reviewer thought the Tier 1 suppliers have a lot to offer.

Reviewer 3:

The reviewer expressed a desire to see what the potential users think of the analytical tool. The ability of different users to plug in their own high-fidelity models of their engines and electric power generation capability would ensure a long life for this tool. The reviewer added that the types and amounts of collaboration, while not explicitly discussed, seem appropriate at this developmental stage.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer pointed out that the program is about done. Delivery of tools that are robust for the few industry stakeholders is a crucial deliverable for success.

Reviewer 2:

The reviewer commented that the proposed future research is a logical progression that increases the value of this project's products.

Reviewer 3:

The reviewer reiterated the desire to see further study on zoning or targeted cooling areas.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer noted that this is very relevant and oftentimes a forgotten fuel use for over-the-road Class 8 tractors. Drivers live in these vehicles and are only allowed to drive 10 hours per day and rarely is slip seat operation maximized. The reviewer added that this is important work.

Reviewer 2:

The reviewer stated that hoteling in line haul trucks can use as much as one gallon of fuel an hour. Battery or no-idle solutions are heavy and expensive. The reviewer added that any technology that can reduce the thermal load would benefit enormously in energy requirements.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said good use of resources and speculated that with more funding more validation testing could have been performed.

Reviewer 2:

The reviewer stated that funding seems sufficient and efficient use to have been made of it, given activities completed.

A Complete Vehicle Approach to the SuperTruck Challenge: Pascal Amar (Volvo Trucks) - vss081

Presenter

Pascal Amar, Volvo Trucks.

Reviewer Sample Size

A total of three reviewers evaluated this project.

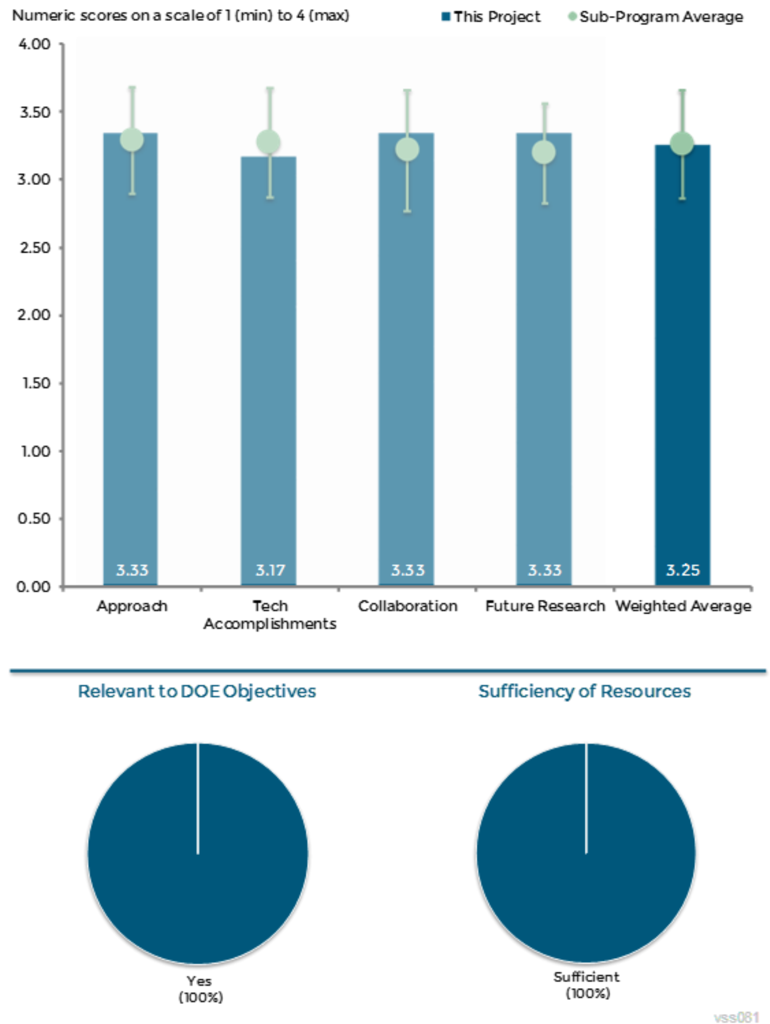


Figure 1-11 A Complete Vehicle Approach to the SuperTruck Challenge: Pascal Amar (Volvo Trucks) -Vehicle Systems

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that the approach taken is quite comprehensive, including many beyond state-of-the-art technologies, which should be adequate to help the program achieve its goal. It would be helpful if the final vehicle demonstration can use the same routes as its competitors in Texas, which can provide more or less apple-to-apple comparisons

Reviewer 2:

The reviewer was somewhat disappointed with this review. The reviewer said that 80% of it was discussing commercializing trailer aerodynamics. The reviewer believed that Volvo's approach and accomplishments are strong, but expected to see evidence of it during this review. For instance, the reviewer thought it appropriate that reviewers are shown a test plan for the demonstrator vehicle going forward, validation of concept performance predictions, plans to test over the road, etc., but none was provided.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer said excellent, believing that the accomplishments are there even though little evidence was shown other than the truck chassis has been built. The reviewer would have liked to see how the detailed designs and prototyping met expectations. The reviewer then asked what the major successes, issues, and problems were, and how were they overcome.

Reviewer 2:

The reviewer commented that there is no final vehicle MPG or improvement mentioned compared to last year's progress, although it reports quite a bit intermediate accomplishments. So, it is hard to judge the program progress.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer reported that there was not a very long list and nothing new was shared on collaboration successes to show evidence that there is extensive learning from this effort across all parties.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer believed there is a plan for the final year of effort, which was not shared.

Reviewer 2:

The reviewer remarked that it looks promising to achieve the program goals.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that many technologies proposed and being used have potential to be put into production in the 2020-2025 time frame. Therefore, this project supports the overall DOE objectives of petroleum displacement.

Reviewer 2:

The reviewer said HD Class 8 tractor-trailer fuel efficiency is the single biggest action we can take in petroleum reduction in transportation.

Reviewer 3:

The reviewer stated that the project demonstrated MGP improvements and had good plans for phase two.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said it is amazing to use half the budget of their competitors to achieve the same program goal. Well done.

EV - Smart Grid Research and Interoperability Activities: Keith Hardy (Argonne National Laboratory) - vss095

Presenter

Keith Hardy, Argonne National Laboratory.

Reviewer Sample Size

A total of five reviewers evaluated this project.

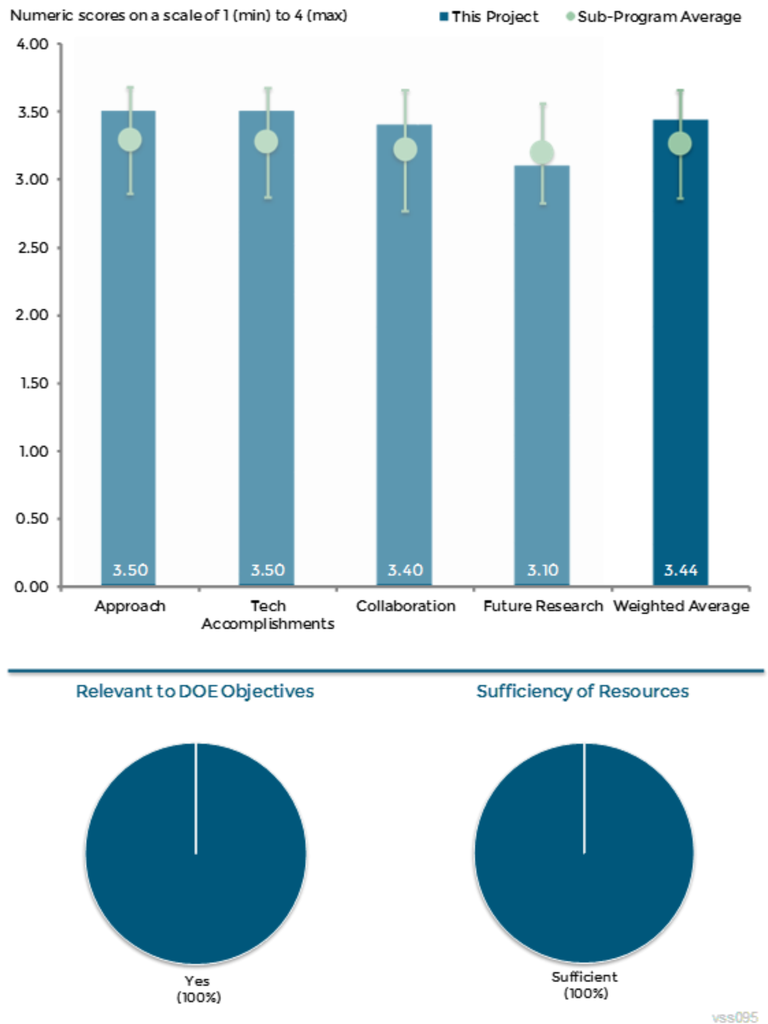


Figure 1-12 EV - Smart Grid Research and Interoperability Activities: Keith Hardy (Argonne National Laboratory) - Vehicle Systems

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer observed that there were no issues. This, the reviewer believed, is a necessary activity, and the national laboratories are best positioned to lead this it.

Reviewer 2:

The reviewer commented that standards are clearly a great role for DOE and the laboratories. It is not entirely clear how important the lab testing described is supported by industry and coordinated with similar testing being done in industry.

Reviewer 3:

The reviewer said the approach seems appropriate, although there was not much information in the package on approach.

Reviewer 4:

The reviewer pointed out that the overall driving impetus behind EV-Smart Grid Research and U.S. – European Union (EU) interoperability is to be the technology, systems, communications, and standards leader to drive interoperability of PEVs worldwide. If the United States and E.U. are not the leaders, China will become the de facto leader, which will have serious negative consequences for U.S. competitiveness in the vehicular development/commercialization and grid communications space. The reviewer added that working hand-in-hand with the E.U. is a force multiplier to strengthen the U.S. position in this area and maintain a competitive edge with regard to electric-drive vehicles, infrastructure, and grid communications, as well as grid robustness and enhanced utilization of renewable energy sources. The reviewer also said that the approach of joint U.S. and E.U. interoperability centers, parallel SAE and International Organization for Standardization (ISO)/International Electrochemical Commission (IEC) standards development, standardized verification tools, and specifications for a common U.S.-E.U. test device is a strong approach to accelerate and harmonize the

United States and E.U. around global EV interoperability requirements. Additionally, the focus on a common integration platform with open-source control architecture and software is a good approach enabling seamless grid integration of a variety of distributed energy resources, HVAC, and metering elements.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer stated that the harmonization activity (BMW i3 testing) appears to be progressing quite well.

Reviewer 2:

The reviewer commented that it appears that ANL has moved the standards efforts along well and made important contributions.

Reviewer 3:

The reviewer said that there have been technical accomplishments on a number of fronts, including facilitating development of standards including associated development of compliance tools and test procedures, development of embedded controls, EV/EVSE/grid communication modules, and sensing and metrology equipment. Prototype E.U.-U.S. AC interoperability test equipment has been developed, a common test vehicle settled upon (BMW i3 EREV), and the development of a standard integration hardware-in-the-loop (HIL) platform is underway. The reviewer added that a common integration platform with open-source software and control architecture is being developed.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that there appears to be close collaboration and coordination with other institutions domestically and overseas, primarily through the joint codes and standards activities including SAE/ISO-IEC/National Institute of Standards and Technology (NIST)/Institute of Electrical and Electronics Engineers (IEEE) and the Global InterOP Team. This collaboration/coordination has been and is an ongoing effort essential to overall success of the project. The reviewer assumed that relevant industrial participants (such as controls manufacturers, home energy service companies, EVSE manufacturers, etc.) are represented within the codes and standards committee structure.

Reviewer 2:

The reviewer said no issues here.

Reviewer 3:

The reviewer reported that clearly the team is coordinating with SAE but there are so many other organizations involved in this space and the reviewer did not see any mention of these.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer noted that the proposed future work is well delineated into several areas including codes and standards committee support, embedded controls and communication, sensing and measurement, testing infrastructure, and integrated verification/hardware studies with a final goal of technology transfer in 2018. This structure provides the framework for moving forward over the next several years, realizing that milestones are determined by committees and may change. The reviewer added that the structure lays out a logical sequence of tasks being driven from the top level by joint U.S.-E.U. codes and standards committee decisions.

Reviewer 2:
The reviewer observed no issues.

Reviewer 3:
The reviewer commented that standards always seems to be a never-ending sink for resources. While this is important, the reviewer would like to see a clear path toward an end goal with a limit on the resources.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer pointed out that standardization would improve the chances of large-scale acceptance of these technologies.

Reviewer 2:
The reviewer commented that this project is highly relevant to the overall DOE objectives of petroleum displacement because for electric drive vehicles to transition from the early adopter phase to the broader mass market will require an improved value proposition and mitigation of present consumer concerns including limited range and associated driver anxiety. The reviewer added that improving the interoperability of the EV/ EVSE/grid space will potentially permit EVs to provide value-added services to the grid/home and will broaden access to recharging infrastructure helping to alleviate range anxiety. These developments can potentially contribute to a cascading effect whereby battery sizes could be reduced (due to expanded availability of recharging infrastructure) thus reducing vehicular costs.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer repeated the observations of reviewers from the previous year that resources are probably sufficient to address the SAE activities, but insufficient to cover some of the other activities.

Reviewer 2:
The reviewer said inconclusive, funding information is not provided

Reviewer 3:
The reviewer reported that it is difficult to value this effort compared to other needs for resources.

Testing of Wireless Charging Systems for Codes and Standards Development: Barney Carlson (Idaho National Laboratory) - vss096

Presenter

Barney Carlson, Idaho National Laboratory.

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

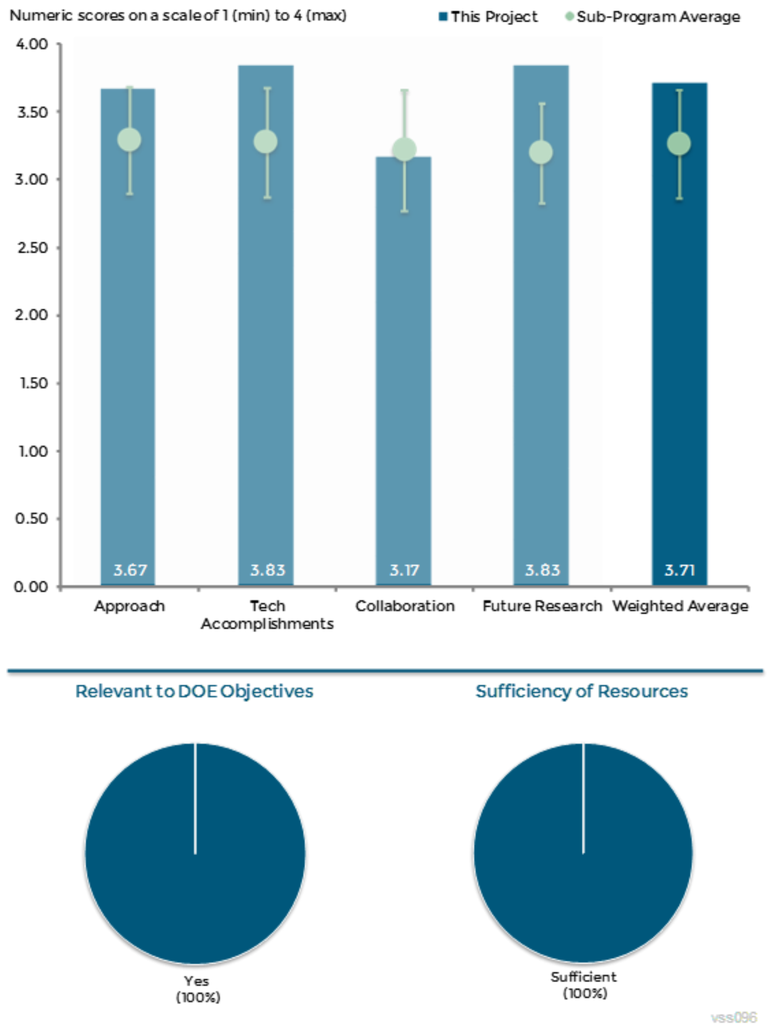


Figure 1-13 Testing of Wireless Charging Systems for Codes and Standards Development: Barney Carlson (Idaho National Laboratory) - Vehicle Systems

Reviewer 1:

The reviewer commented that there was excellent testing setup and coordination with other relevant regulatory authorities. The primary value is in helping to establish standards and procedures for wireless and EVSE test equipment. The reviewer added that the independence provided by a government-funded laboratory is also invaluable.

Reviewer 2:

The reviewer said that there was a thorough job of testing the equipment and clear, concise reports on the INL website.

Reviewer 3:

The reviewer reported that this is an essential program in the adoption of EVSE technology. Effective standardization will result in greater efficiency and reduced safety issues to the end user (John Q. Public), thus lowering the barrier for mainstream acceptance of EV technology; however, the reviewer is anxious that DOT is independently moving forward in the Global Technical Regulation (GTR) process defining safety performance test procedures and pass/fail criteria without any reference to this work. It is noteworthy to point out that their assumptions may negate some of the outcome of this project. The reviewer expressed great concern about the breakdown of communication between DOE and DOT that has occurred in the past year and half. This breakdown is exemplified by this project, and it is one that must be rectified. In addition, on June 16, 2015 Argonne National Laboratory was awarded funding by DOT intended to support development of test protocol and pass/fail criteria for this GTR regulation.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer remarked that there was excellent technical output that contributes to the advancement of wireless charging technology.

Reviewer 2:

The reviewer noted that quantifying the magnitude of the difference between bench and in-vehicle is an important contribution; however, the reviewer asked how the project comes to terms with the rather low in-vehicle charging efficiency (Chevy Volt), compared to the higher in-vehicle efficiency numbers claimed by Hyundai in vss102. The reviewer also asked if there are any plans to evaluate the charger being used in the Hyundai. Because the stated objective is to provide unbiased and independent testing for wireless charging systems, it would make sense to have the Mojo Mobility charger being used at Hyundai tested independently at INL. The reviewer asked if the intent is to test only charging systems from the awardees of funding opportunity announcement (FOA)-667 or is it just logistics (non-availability of the system in the desired vehicle, etc.).

Reviewer 3:

The reviewer reported that the approach was well defined and thus far conducted for assessment. The reviewer would like to see, as part of this program, well defined, and documented, repeatable test procedures for the charging procedures. The reviewer further offered to provide DOE and ANL a Level 3 test procedure.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that the project team could establish stronger ties with ultimate users of the test technology being developed (for example, Underwriters Laboratories).

Reviewer 2:

The reviewer commented that this project was, and is, ripe for greater collaboration with DOT/National Highway Safety Administration (NHTSA) to define Safety Performance metrics for regulatory purposes.

Reviewer 3:

The reviewer pointed out that the partners to this project are listed as EPA ENERGY STAR®, Evatran LLC and the SAE Standards Committee. In the Accomplishments (Slide 13), the testing of EVSE equipment from four awardees of FOA-554 (GE, Eaton, Delta, and Siemens) was mentioned. The reviewer asked if these companies are not partners on this project.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer noted that several conductive systems and a couple of wireless charging systems have been tested. It would be great if INL also published comparisons of all the different charging systems in one report.

Reviewer 2:

The reviewer stated that the project team is continuing their current activity. The reviewer then asked if there are opportunities for expansion of scope.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer said that advanced technology is needed for making EVs more mainstream.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer directed attention to previous comments. If the testing is restricted to a few (wireless or conductive) charging systems primarily because of budget constraints, perhaps there is merit to increasing the budget a little to allow a wider range of testing to be done.

Reviewer 2:

The reviewer commented that the resources appear to be sufficient given the scheduled work.

Electric Drive Vehicle Climate Control Load Reduction: John Rugh (National Renewable Energy Laboratory) - vss097

Presenter

Matthew Jeffers, National Renewable Energy Laboratory.

Reviewer Sample Size

A total of three reviewers evaluated this project.

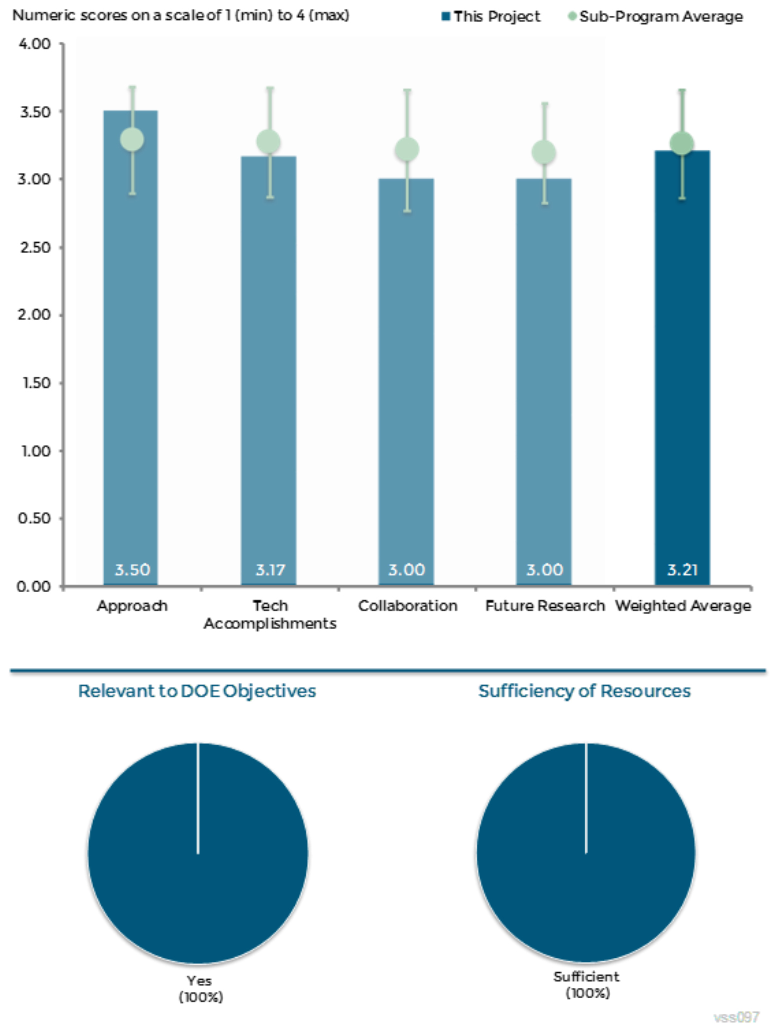


Figure 1-14 Electric Drive Vehicle Climate Control Load Reduction: John Rugh (National Renewable Energy Laboratory) - Vehicle Systems

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commented that the tools and instrumentation used are effective. The reviewer added that the question is how the thermal comfort evaluation method addresses the subjectivity of the heat or A/C acceptance performance.

Reviewer 2:

The reviewer said that after a couple years of work in this area, the path toward achieving the goal (10% improvement on EV range) is not clear. With so much emphasis on the transient cool-down or warm-up periods it was not apparent from the presentation that the major deterioration of range in hot or cold weather is getting the most attention. The reviewer added that perhaps the researchers have other data that these transient periods deserve the most attention toward meeting the range goal.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer commented that the data shown was well illustrated. The reviewer emphasized that it would have been good to show how many vehicles and types were tested.

Reviewer 2:

The reviewer stated that some presentation of an organized path toward the 10% goal would be helpful. Pieces of data show promise, particularly with the supplemental direct ducting to the occupant. The reviewer added that if reducing the starting cabin temperature (from solar load, etc.) in the case of A/C is not a major contributor to increasing the range over the total driving cycle then the emphasis on evaluating potential improvements versus focusing on features for steady-state efficiencies may be unwarranted.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted that it would be good to illustrate the specific type of collaboration between partners, other than just listing who they are.

Reviewer 2:

The reviewer assumed there was good collaborations, good partners (including a Ford cooperative research and development agreement [CRADA]) but an HVAC auto system supplier is seemingly absent.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer suggested having real-world evaluation to assess the consumer's acceptance of the proposed design changes.

Reviewer 2:

The reviewer stated that the project team is in the last year of project, and it is not clear if objective will be met to logically wind down the activity

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that this topic is very relevant to DOE objectives of more efficient EVs and enabling technologies because cabin HVAC is a major source of range deterioration.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer assumed that funding was sufficient, there being no evidence of a resource shortage in the information presented.

High-Efficiency, Low-EMI and Positioning Tolerant Wireless Charging of EVs: Allan Lewis (Hyundai) - vss102

Presenter

Allan Lewis, Hyundai.

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

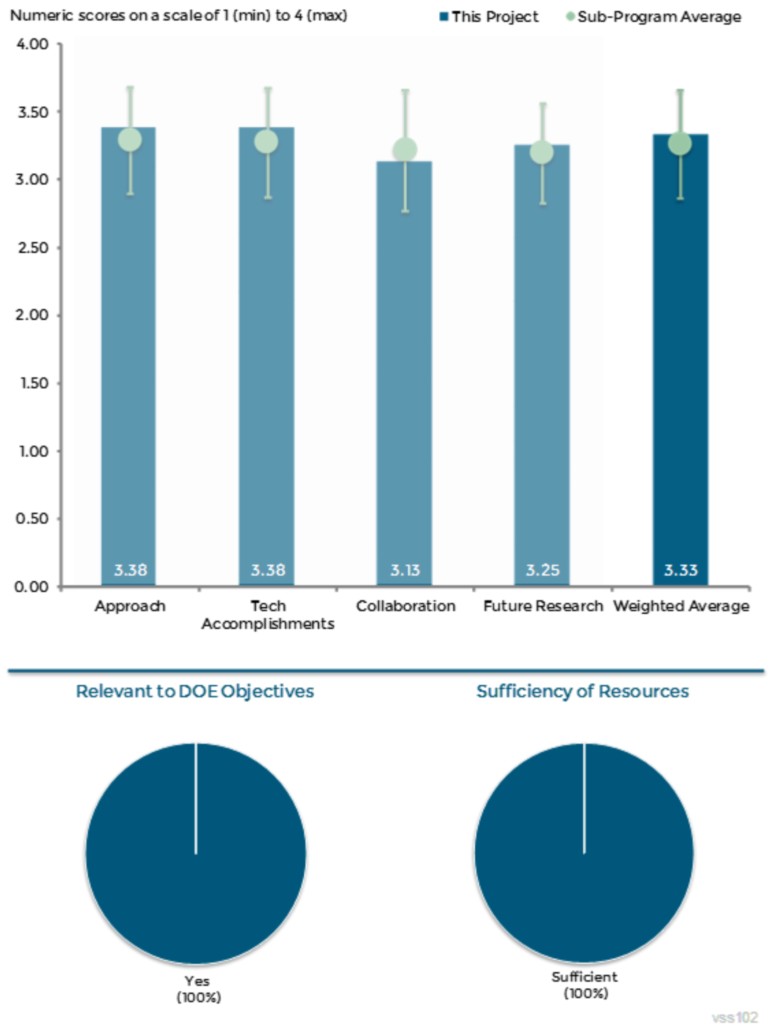


Figure 1-15 High-Efficiency, Low-EMI and Positioning Tolerant Wireless Charging of EVs: Allan Lewis (Hyundai) - Vehicle Systems

Reviewer 1:

The reviewer reported that the approach enables interoperability because this wireless power transfer (WPT) uses the industry standard 85 kHz, and the approach is recognized for the stretch goal of high power transfer (over 20 kW). Also the approach of a stretch goal of greater than 6.6 kW is important for possible future MD and HD application.

Reviewer 2:

The reviewer commented that the overall project approach involved progressing the developed WPT system through three benchtop generations and will next involve integrating and demonstrating the system on five test vehicles. This approach of refining the system on the bench before taking it into the demonstration vehicles seems prudent. Indeed, the presentation highlighted good technical progress with each benchtop iteration. The reviewer stated that the presenter indicated the benchtop setup was made with no structure around it that might mimic the influence of the vehicle body, and that this was done to demonstrate worst-case electromagnetic emissions. While it is good to make such worst-case observations, it would have been helpful to evaluate some benchtop scenarios with a mocked-up vehicle body surrounding it in order to sanity check the modeling estimates about impacts on efficiency and electromagnetic emissions in a more realistic test scenario.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer stated that technical progress showed much success, and most importantly, showed shortcomings and discussions centered on addressing those.

Reviewer 2:

The reviewer listed the project accomplishments, which included: reducing the footprint of the system through the three benchtop generations; improving the design to a roughly 20 kW power capability (though it has only been tested to 10 kW, which is higher than the official 6.6 kW project goal); demonstrating improving efficiencies in each generation—achieving wall-to-receiver efficiencies over 90% for the benchtop demonstration (of similar magnitude to conductive charging); demonstrating electromagnetic emissions below international standards in most cases;, and identifying an engineering need to address E field emissions along the length of the vehicle, which the presenter felt should not be a problem once the team starts to introduce shielding during the vehicle integration phase.

Reviewer 3:

The reviewer noted that the technical accomplishment is good but appear to be delayed/behind schedule in comparison to 2014 AMR vss102 slides timeline and progress. The demonstrated direct current (DC)-to-DC efficiency of up to 96% across a wide misalignment tolerance is a very good accomplishment. The reviewer added that as well as the low emissions measurements field emissions around the system. The timeline since Phase 2 demonstration (February 2014), for example, integration into vehicle, appears to be in slight delay. The reviewer also said that it has been more than a year since the Phase 2 demo and the vehicle integration is still in progress.

Reviewer 4:

The reviewer indicated that E field measurements appear to be at the edge of safe emissions limits set by International Commission on Non-Ionizing Radiation Protection (ICNIRP) in 2010 for the general public. Commercial product designs usually provide a safety margin that ensures system operational states that are well within the safety region. The reviewer added that the project team should work on increasing the operational safety margin with respect to E field exposure for the prototypes.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that collaboration is good. Mojo Mobility has significant WPT system experience, and Hyundai has significant automotive manufacturing experience. The reviewer also commented that this collaboration has the necessary elements for a potential production WPT.

Reviewer 2:

The reviewer reported that the collaboration appears to be good between Hyundai, the Mojo Mobility sub-recipient, SAE International, and Next Energy.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer pointed out that the proposed work appears to be focused on integration and validation. It would be nice to see a plan for high power demonstration.

Reviewer 2:

The reviewer noted that the project is pending approval to extend the project beyond the originally scheduled end date, and the future work seems appropriately focused on integrating the Gen 3 benchtop prototype into five test vehicles. It seems it might be a good idea to perform the integration on one or two vehicles first, in order to uncover any unforeseen issues before completing integration on the last few. The reviewer added that the presenter also made encouraging comments about a commercial viability study indicating that the system may be commercializable at a reasonable price point following the end of the project.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer remarked that development and demonstration of wireless chargers are critical for advancing EVs in the marketplace. This work facilitates the progress of charging technologies.

Reviewer 2:

The reviewer stated that wireless charging with interoperability capabilities promotes more electric miles traveled by ease of use for consumers as well as reduced occurrence of forgot-to-plug-in.

Reviewer 3:

The reviewer commented that the project is relevant to DOE’s petroleum displacement goals as it stands to make vehicle charging more convenient and automatic, which could make PEVs more attractive and able to displace greater amounts of petroleum.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer reported that the resources appear to be sufficient for this large project which includes the development of a high-power WPT system as well as its integration into a production EV.

Reviewer 2:

The reviewer stated that the project seems to be progressing on or under budget.

Wireless Charging: Omer Onar (Oak Ridge National Laboratory) - vss103

Presenter

Omer Onar, Oak Ridge National Laboratory.

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

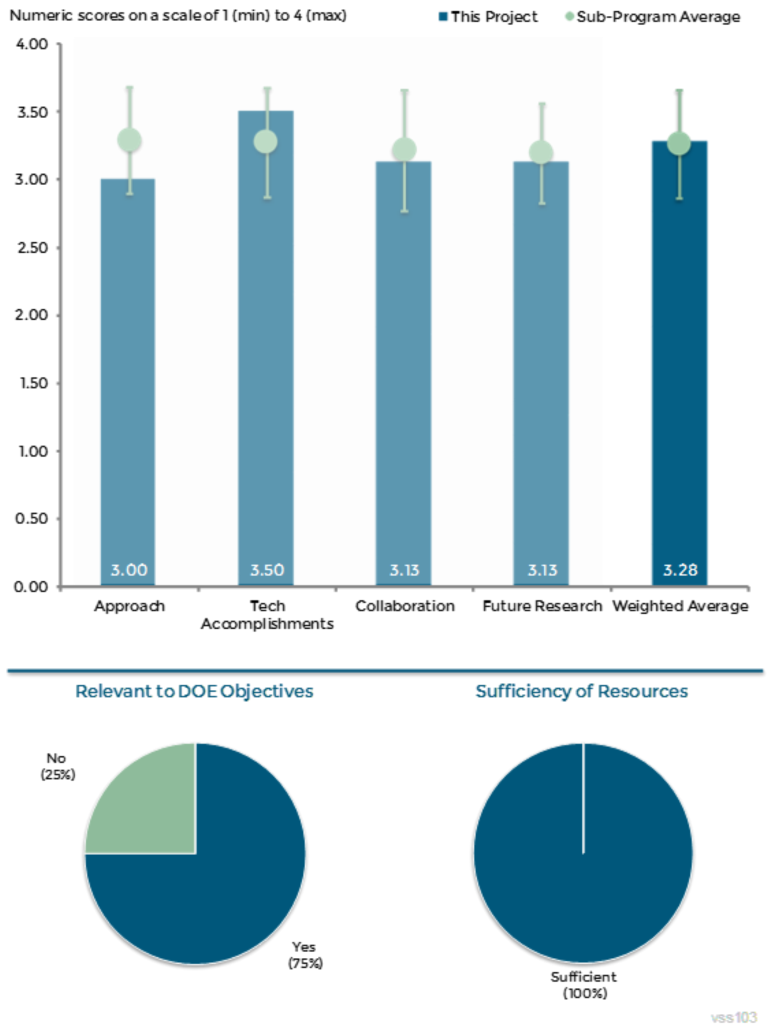


Figure 1-16 Wireless Charging: Omer Onar (Oak Ridge National Laboratory) - Vehicle Systems

Reviewer 1:

The reviewer stated that there was a very thorough project design and execution. The program has advanced the state of the art and is wrapping up with good results.

Reviewer 2:

The reviewer commented that the approach taken is beneficial in providing a path for wireless charging. The one item the reviewer questioned is the underlying benefits toward standardizing the protocols and standards.

Reviewer 3:

The reviewer indicated that the impact of integration with physical infrastructure, i.e., pavement, should be considered early on, as it may have an impact on vehicle integration.

Reviewer 4:

The reviewer indicated that Oak Ridge National Laboratory's (ORNL) approach still seems to be at odds with the SAE J2954 standards, in terms of the central frequency. Despite designing a power electronics component that can operate at this frequency, the rest of the work appears to be using a different frequency than what has been decided upon by the SAE J2954 committee. The reviewer added that it was reasonable at last year's AMR for ORNL to continue on this path because the SAE committee had not fully committed to 85 kHz; however, now that this decision has been made, the work that ORNL is doing at 22-26 kHz is only marginally useful.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:
The reviewer said that it appears all objectives have been met or exceeded. The technical work is very impressive.

Reviewer 2:
The reviewer observed that the work to date is progressing according to plan.

Reviewer 3:
The reviewer commented that there has been some slippage in milestone dates, and the delay between the first milestone demonstrations of the bench test to the in-vehicle demonstration of the second milestone (1.5 years expected)) seems unduly long.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer pointed out that coordination with appropriate partners is very good, including proof-of-concept vehicles. The reviewer asked if there will be technology transfer or commercialization.

Reviewer 2:
The reviewer did not see the larger scope of involving other OEMs and suppliers to achieve a common standard and protocol.

Reviewer 3:
The reviewer stated that there appears to be a good level of collaboration for this project; however, the reviewer wondered why INL has not been brought into this project with their wireless charging test setup. The reviewer asked if this is something that ORNL plans going forward.

Reviewer 4:
The reviewer reported that collaboration with DOT is not described. This is a concern because there may be some advantage to at least recommend to DOE that this coordination take place, especially in terms of physical infrastructure, for example, placement in pavement. The reviewer added that the interaction with SAE J2954 should be described, as well as the potential impacts of their efforts on this project.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer commented that the development was probably too far along to change once the J2954 committee made its decision, but there seems to be no contingency plan to mitigate the possibility that the committee would make the decision they did. Otherwise, the planned future work seems logically organized.

Reviewer 2:
The reviewer stated that although the impact of infrastructure on project objectives is listed as a barrier, there is no recommendation for considering it as the project moves forward, or as a follow-on project.

Reviewer 3:
The reviewer recommended engaging other enterprises in this project, as a next step, to drive a common standard and implementation protocol. The project outline did not specify clearly the eventual outcome of the project.

Reviewer 4:

The reviewer pointed out that the project is completed in FY 2015.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer noted that this not only supports DOT objectives, but also the DOT Clean Transportation Sector Initiative goals of 80% GHG emissions reductions by 2050, as well as EPA objectives.

Reviewer 2:

The reviewer stated that the project facilitates adoption of EVs by making the charging process simpler.

Reviewer 3:

The reviewer indicated that WPT is seen by a significant proportion of industry observers as having high potential for consumer acceptance that could increase the attractiveness of PEVs; however, this project does not advance the state of the art of WPT because the standard has moved away from the project's design.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that resources appear to be sufficient.

Reviewer 2:

The reviewer remarked that the resources appear to be sufficient for the stated milestones.

Zero-Emission Heavy-Duty Drayage Truck Demonstration: Brian Choe (SCAQMD) - vss115

Presenter

Brian Choe, SCAQMD.

Reviewer Sample Size

A total of three reviewers evaluated this project.

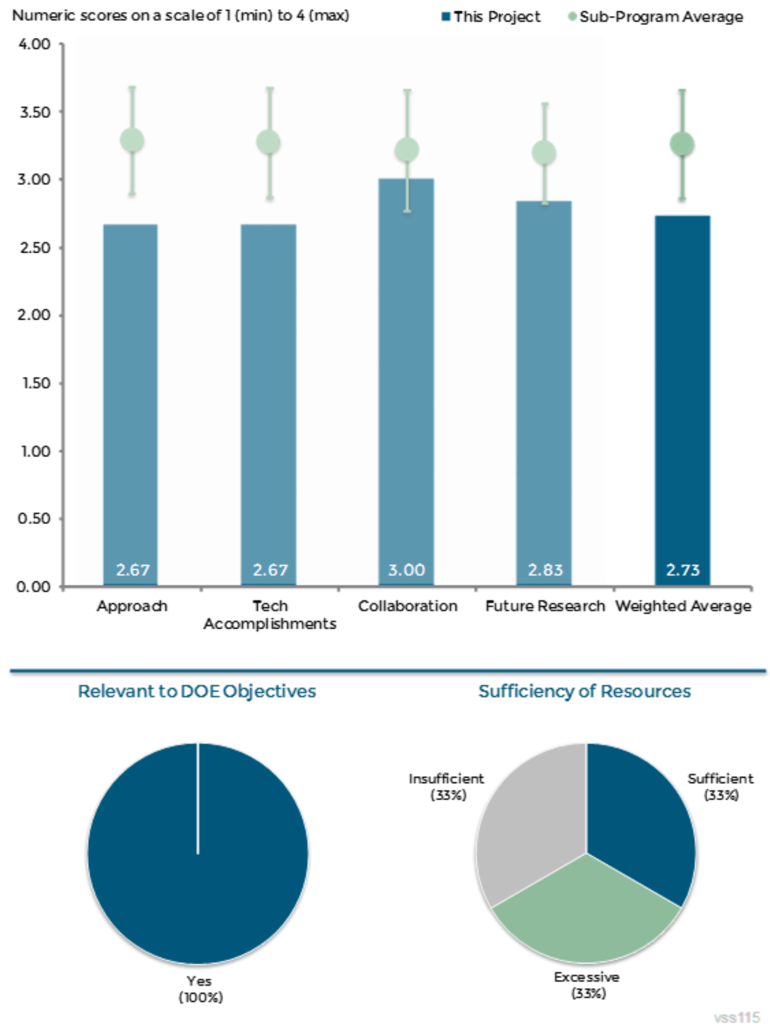


Figure 1-17 Zero-Emission Heavy-Duty Drayage Truck Demonstration: Brian Choe (SCAQMD) - Vehicle Systems

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that this is a challenging project for such an R&D-focused demonstration. It is obvious that the program always had uptime challenges and it is unfortunate that the program is behind. The reviewer added that the approach should have had more failure mode effects analysis (FMEA) type actions to meet deliverables on time, though the program is progressing.

Reviewer 2:

The reviewer reported that the program would benefit from a strong technical lead, given its significant development and manufacturing component. A technical lead by an OEM or technical partner would be familiar with and have experience in addressing the technical challenges. The reviewer added that having different technologies (two different BEV architectures and later a natural gas [NG] HEV) to the program doubles/triples the development and manufacturing scope and effort beyond that originally planned. It would be advisable to focus on completing one BEV architecture alone to maximize the learnings from that technology in service, before embarking on technology number two and number three.

Reviewer 3:

The reviewer stated that, with an overall goal to demonstrate zero emission drayage trucks, the approach is good. It is challenging to get functioning prototypes out on the road for the first time. The reviewer added that it is not clear what mechanisms are in place to capture the operational issues with these vehicles. NREL will collect the quantitative information on performance, but the reviewer asked about information for each truck type that addresses how well it can replace the current baseline vehicles. Things like the percentage of routes it can cover and any performance anomalies that would dissuade a fleet operator from acquiring a certain design/technology are potentially important.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:
The reviewer commented that the existence of operational zero emission drayage trucks is a breakthrough by itself.

Reviewer 2:
The reviewer commented that notwithstanding all the challenges, trucks are built and overcoming uptime and performance issues. The reviewer is sure massive learning is going on by the participants. These should be fully documented and shared with as many people as possible, including other manufacturers and interested parties.

Reviewer 3:
The reviewer indicated that significant technical problems led to deployment delays and a two-year extension request. The reviewer would like to see specific performance indicators that quantify the benefits of this technology in service such as fuel saved/emission reduced, etc. compared to baseline.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer reported that collaboration appears to be effective and at an appropriate amount.

Reviewer 2:
The reviewer cited a good team focused on these few trucks for this particular demonstration. The reviewer asked if the project team have or has considered some form of advisory group. This could have other interested parties help with solutions and significant and quick learning. The reviewer was not sure that this is a possibility within the DOE rules on such projects but would love to see this.

Reviewer 3:
The reviewer pointed out that the principal investigator (PI) does work with integration partners TransPower and U.S. Hybrid; however, the integration partners should play a larger role to ensure the functionality of the vehicle and provide adequate support during the deployment phase, because the vehicles put into service are essentially mule vehicles with a high propensity to break down.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer stated that the proposed work is a logical progression of the current effort.

Reviewer 2:
The reviewer recommended that the project team complete the deliverables and document all learnings.

Reviewer 3:
The reviewer commented that the addition of an NG HEV architecture unnecessarily expands the scope of the project and introduces significant additional technical risk which the project cannot afford. The reviewer advised that the project team focus on existing HEV architectures and collect more data on them to gain a better understanding of the benefits.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer reported that although there are only few drayage trucks in the country, their regions of operation cause real issues with air quality, etc. The great news is that we have an early adopting vocation/duty cycle that can help demonstrate a potential long-term petroleum replacement solution for a great deal of other truck applications.

Reviewer 2:

The reviewer said that technically this program contributes to petroleum displacement; however, the drayage application is not a major contributor to petroleum consumption by commercial vehicles on a national scale. Even the most successful outcome of a drayage application will not result in a large dent in fuel consumption, because the technologies deployed in a drayage application will not translate well to long-haul trucking where most of the fuel is consumed.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer guessed that this has to be insufficient as many of the partners are pulling out.

Reviewer 2:

The reviewer said that not much money was spent in the first years of the program. It will be difficult to make up the spend.

Zero-Emission Cargo Transport Deployment Projects: Nicholas Williams (Houston-Galveston Area Council) - vss116

Presenter

Nicholas Williams, Houston-Galveston Area Council.

Reviewer Sample Size

A total of four reviewers evaluated this project.

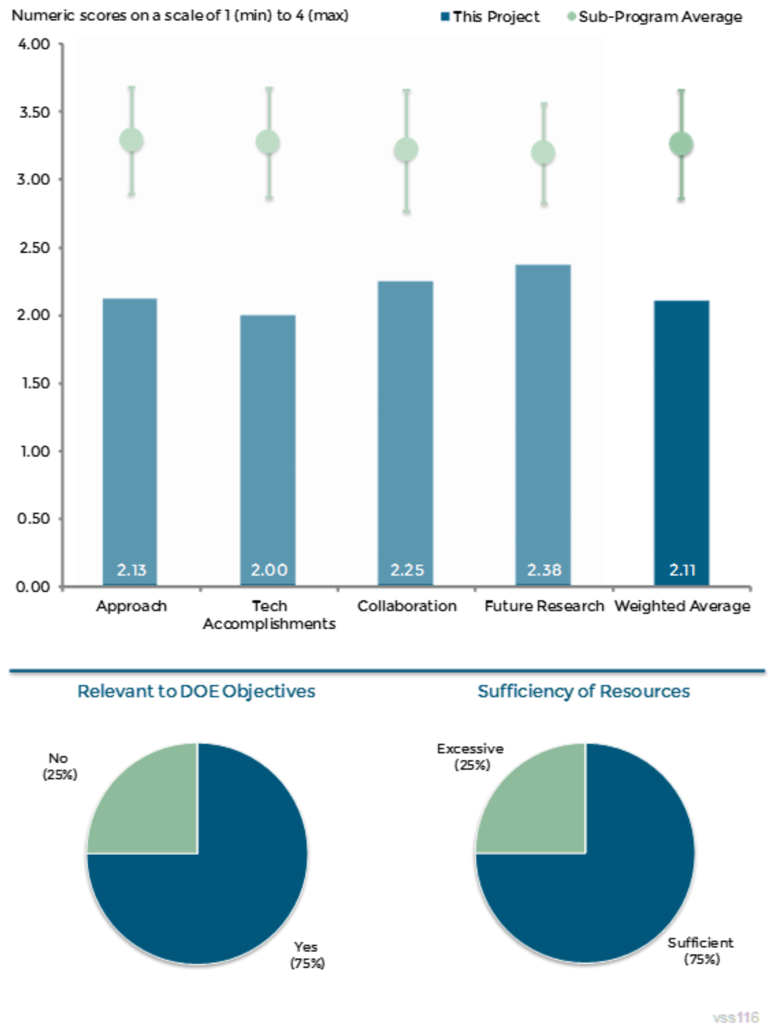


Figure 1-18 Zero-Emission Cargo Transport Deployment Projects: Nicholas Williams (Houston-Galveston Area Council) - Vehicle Systems

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that though there has been limited progress from last year, and the selection of fleet partner should ensure some level of evaluation, there needed to be simulation of largest benefits from this type of technology deployment to ensure industry support. The reviewer added that the technology maturity level may not have been appropriate for full vehicle deployment without a vehicle integration partner with substantial committed resources, an appropriate infrastructure partner and appropriate technology resources to plan both primary and auxiliary plan to acquire useful information that could be better used to project benefits of technology deployment versus other infrastructure deployment.

Reviewer 2:

The reviewer pointed out that unfortunately, this project has a risk of producing demonstration data contrary to wide acceptance as it may re-emphasize the extent of the barriers.

Reviewer 3:

The reviewer commented that the project from the hydrogen (H_2) and EV side is well behind schedule; problems associated with partnership required new contracting.

Reviewer 4:

The reviewer noted that two of the key items on the presentation's Approach Slide were to make sure that the deployed technologies are available and that they are cost-effective; however, these elements are contradicted by the limited vehicle availability through the first two-and-a-half years of the project and the plan to use huge subsidies to fund the vehicle purchases with no clear plan of how to ultimately make the technology cost-effective. The reviewer added that, when asked about how commercial viability might ultimately be achieved, the presenter could not offer any concrete details and simply stated that the hope would be that prices would ultimately come down and that the project team hopes the demonstration will increase exposure and interest in the technology. The reviewer would have preferred to see the approach lay out a precise vision for how the project will help overcome commercialization barriers and give detailed plans on data to be collected and comparisons to be made with traditional cargo transport powertrain technologies.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer noted that the first year reporting period had very little funding spent, due to difficulty engaging appropriate partners. Scope change to reduce number of trucks required should have allowed new focus to evaluate various vehicle technology potentials and commercial viability.

Reviewer 2:

The reviewer reported that this area of technology application is critical in achieving meaningful reduction in petroleum use as this sector uses over 60% of the resources; however, the barriers are very real and this project defined them very well.

Reviewer 3:

The reviewer stated that the presentation’s one slide of accomplishments was not very encouraging for a project that began in October 2012. For the most part accomplishments consisted of adjusting partnering arrangements, project plans and issuing a call for proposals. The reviewer added that it would have been nice to see more technical detail, such as specification requirements and selection criteria for respondents to the proposal call, or projected performance for the vehicle designs from the winning proposers.

Reviewer 4:

The reviewer commented that vehicles have not yet fully been procured, and are behind schedule. This project requires some attention in getting these vehicles into fleet.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer pointed out that there was a problem with the initial partners. This project could use additional support and technical knowhow from a large OEM.

Reviewer 2:

The reviewer said that, based on the project delays and challenges encountered, the project does not seem to have had very effective collaboration and coordination to this point. It is particularly disappointing that financial collaboration from state and local entities seems to have fallen through entirely.

Reviewer 3:

The reviewer stated that the project may have benefited by a more direct relationship to the SuperTruck programs and leveraged combined resources.

Reviewer 4:

The reviewer noted that difficulties in obtaining vehicles (and partners) is indicative of the technology readiness for this type of vehicle mission (duty cycle) and an inability to make a strong business case in the near-term without substantial incentives or regulation involvement.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer indicated that with the exception of the award to United Parcel Service (UPS) for AMP to deliver 16 electric delivery vehicles, all the substantive project work remains in this future work category. Given the challenges to date, the most logical plan may be to complete work with UPS and the AMP vehicles and cut losses on the remainder of the project. The reviewer added that if the project is to be extended, the approach shortcomings should first be addressed with a clearer value articulated, to include at this point making a compelling justification for the value to be realized beyond that from the much farther advanced Zero-Emission Drayage Truck demonstration in Southern California.

Reviewer 2:

The reviewer stated that the approach described is solid and hopefully can produce meaningful data for hydrogen fuel cell and EV hybrid acceptance into the field.

Reviewer 3:

The reviewer reported that there are barriers in getting the procurement and implementation of the vehicles into the fleet.

Reviewer 4:

The reviewer said it appears there is an appropriate plan to complete the initial intended deliverables, though the delays raise questions concerning the capability of this team to meet the planned goals.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that while it does in theory, though there should be a minimum requirement to model and indicate vehicle technology benefits and cost in near and longer terms.

Reviewer 2:

The reviewer noted that successful commercialization of fuel cell trucks for port operations and of BEVs for parcel delivery would certainly help displace petroleum, but the focus of this project seems to have had challenges navigating bureaucratic obstacles. The reviewer added that the presenter was not able to make a compelling case for how the project helps address key barriers from DOE's Multi-Year Program Plan (MYPP) or how it could ultimately help realize national benefits through viable commercialization of the proposed technology, so this does not seem to be a very relevant use of Federal funds.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that in addition to the reasons already conveyed in the previous sections, the project expenditures have been significantly under budget, which is good because next to nothing has been accomplished.

Reviewer 2:

The reviewer said that H_2 hybrids would be excessively expensive. Very little progress has been made with partners, this was modified.

Thermal Control Projects: Dileep Singh (Argonne National Laboratory) - vss132

Presenter

Wenhua Yu, Argonne National Laboratory.

Reviewer Sample Size

A total of five reviewers evaluated this project.

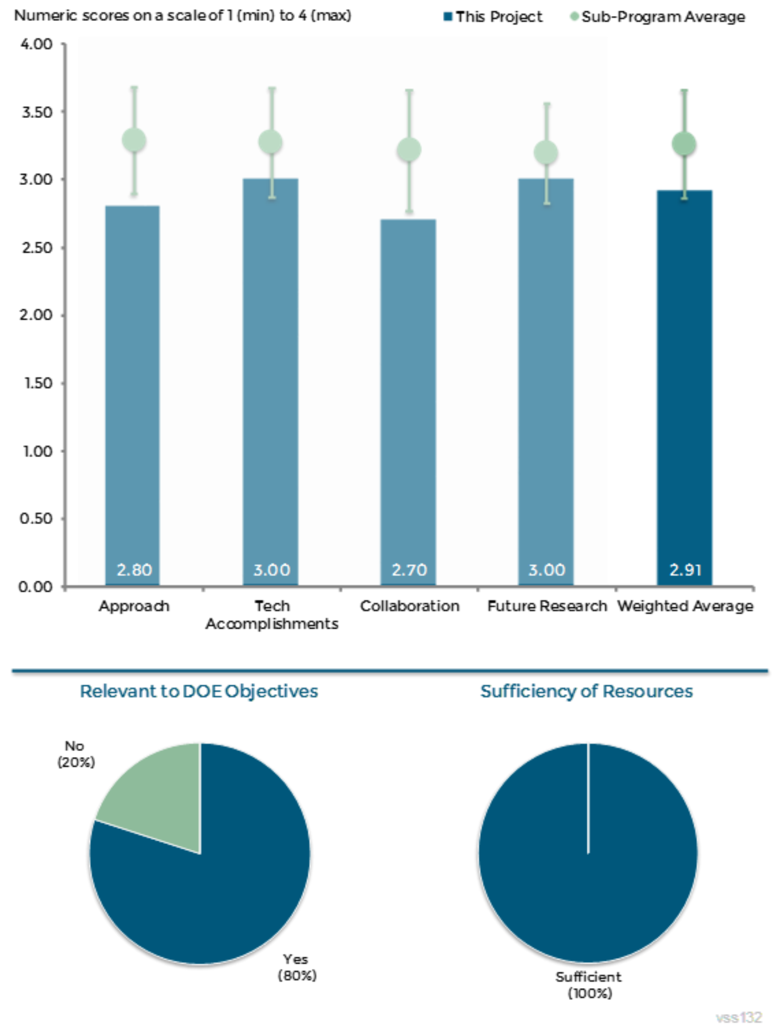


Figure 1-19 Thermal Control Projects: Dileep Singh (Argonne National Laboratory) - Vehicle Systems

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that overall the approach was good. A rough quantification of the potential cost savings associated versus the cost of the cooling system should be considered. In the presentation, more clarity in describing the control variables would be helpful. The reviewer suggested flow rate, power output from power electronics, etc.

Reviewer 2:

The reviewer noted interesting basic research work that may be useful in industry. It is not clear that addressing only inverter cooling would actually lead to eliminating the low-temperature loop due to battery cooling issues.

Reviewer 3:

The reviewer said that in general, this is a very methodical approach. All the work so far revolves around steady-state operating conditions in a lab environment. The reviewer added that more thought should be given to how the system would perform in real-world conditions and the likely challenges that would be faced in making it feasible.

Reviewer 4:

The reviewer commented that the technology being evaluated is relatively old and the reviewer suggested studying more recent technologies for comparison.

Reviewer 5:

The reviewer indicated that the authors need to justify their focus on inverters although the thermal control technology can be applied to any power electronic component. For example, the reviewer asked if it is because of all power electronic components, inverters generate the most heat. The authors need to justify why the team focuses on using a coolant inlet temperature threshold of 105°C (even though it was explained orally during the reviewer's question and answer. The reviewer added that the authors did not explain what the costs, disadvantages, and/or demerits are of subcooled boiling technology in the presentation (although the benefits were explained), see related comment below on collaboration. Also the reviewer pointed out that the authors did not explain why they chose the COMSOL model to provide thermal simulations, when it is a fairly new model and has not undergone the same kind of use and testing as older, more traditional models available.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer noted there was good progress so far. Experimental demonstration of hardware in a transient setting that emulates real-world operation will be critical to the validation of the technology.

Reviewer 2:

The reviewer pointed out that there was good progress on understanding steady-state operating conditions as mentioned before. Reality bites, however, and there should be more effort on accounting for the severity of the underhood environment, and its effect on the behavior of the power electronics module and the coolant system. The reviewer added that transient cycles are mentioned, but it may be necessary to employ some non-standard cycles to test the capability of the system under extreme operating conditions. The standard Federal Test Procedure (FTP) cycles may not be sufficient. The reviewer also stated that improvements to the cooling system as addressed by this project definitely help in reducing fuel consumption, ultimately resulting in petroleum displacement, but the vehicle cannot be sold if it cannot satisfy the operating needs of the vast majority of its drivers. The reviewer also reported that in the previous accomplishments slide (Slide 8), the results of the various studies are very informative, perhaps it would be helpful to look at the impact of variability in the various input parameters. For example, the junction temperature numbers are very precise; the reviewer asked if it would make sense to show it as a band of temperatures within which the temperature could lie.

Reviewer 3:

The reviewer remarked that the design changes shown do provide improvements in the cooling performance; this was done on an earlier generation Prius. The reviewer added that the question was the most recent production Prius evaluated to assess the improvements made.

Reviewer 4:

The reviewer stated that progress is good. Some issues were not clearly spelled out in the presentation, such as how robustly the process of sub-cooled boiling can be maintained in a highly variable ambient environment.

Reviewer 5:

The reviewer had an issue with the simulation predictions even though they so far agree with only the single-phase laminar flow in the Toyota Prius power electronics cooling channel and directed attention to earlier comments under the Approach section concerning use of the model for simulation.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that collaboration with other institutions seems appropriate.

Reviewer 2:

The reviewer said that the project could use some additional automotive industry partners to provide best overview of the problem.

Reviewer 3:

The reviewer commented that the response to last year’s comments indicated that there is no industry collaboration at the current stage because the research activities are at a fundamental level. Following up on the theme of the previous comment, even though what is being carried out is basic research, it would still be beneficial to reach out to industry experts to understand the constraints under which they have to operate, so that these aspects are incorporated into the research plan well in advance.

Reviewer 4:

The reviewer pointed out that the authors should have collaborated formally with Toyota to have the OEM evaluate at least theoretically how practical their thermal control technology (of using subcooled small channel coolant) for the inverter or other power electronic component in the Toyota Prius. The reviewer asked how the Toyota design engineers would view the impact of this technology on the vehicle's maintenance and operation, impacts the authors did not consider.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer said that the project is concluding with good progress.

Reviewer 2:

The reviewer had some additional questions that could be considered in the future, including wide band gap materials that have the ability to withstand higher temperatures. The reviewer asked if a new cooling technology is really necessary with wide band gap, or is the use of engine coolant with existing cooling strategies feasible. Also, improved cooling could be used to eliminate one cooling system, thus saving cost. The reviewer asked if it is possible that improved cooling could also (or instead) be used to improve the power density of the PE. The reviewer also asked what kind of cost savings might be possible from this strategy.

Reviewer 3:

The reviewer commented that using more severe drive cycles may be warranted.

Reviewer 4:

The reviewer had the same comment as above in the approach concerning use of the model for simulation.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer indicated that employing boiling cooling could be an enabler to help eliminate the additional cooling system that is usually required for power electronics in a hybrid system. Elimination of the additional cooling loop should help reduce system costs, making hybrid systems with their associated fuel savings more affordable and more widely adopted.

Reviewer 2:

The reviewer stated that if a workable design (eliminating low-temperature loop) can be arrived at, it would definitely help in reducing cost, improving reliability, and more important, reducing cost and encouraging higher adoption rates for EVs.

Reviewer 3:

The reviewer said that means of reducing propulsion system mass by eliminating low-temperature coolant loop helps improve vehicle efficiency.

Reviewer 4:

The reviewer reported that the authors did not justify the need for this project at the beginning. The project team neither showed how much reduction in dollars-per-kWh could be achieved with this technology nor whether the target of reduction of $8/kWh is feasible. The reviewer added that there is also no demonstration of how much petroleum displacement would occur with achieving this target.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented that the work seems to have adequate resources based on the results presented.

Reviewer 2:

The reviewer said that funding appears reasonable for the significance of this project; if this funding was more than $500,000, the reviewer would raise an objection.

Cummins Medium-Duty & Heavy-Duty Accessory Hybridization CRADA: Dean Deter (Oak Ridge National Laboratory) - vss133

Presenter

Dean Deter, Oak Ridge National Laboratory.

Reviewer Sample Size

A total of five reviewers evaluated this project.

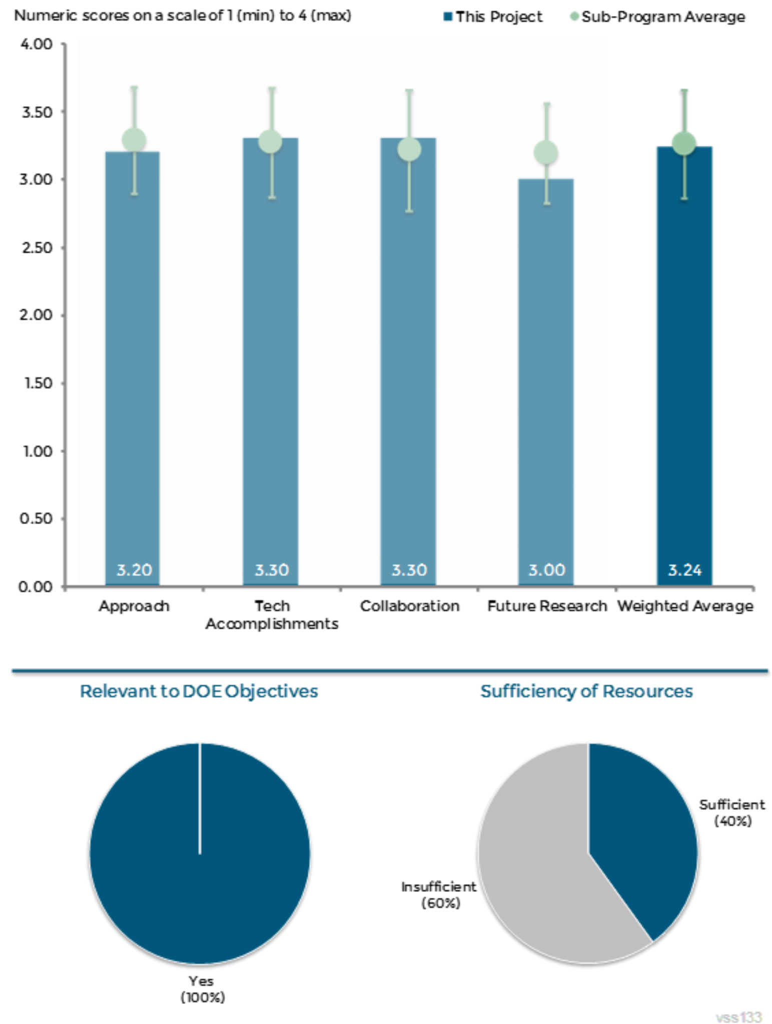


Figure 1-20 Cummins Medium-Duty & Heavy-Duty Accessory Hybridization CRADA: Dean Deter (Oak Ridge National Laboratory) - Vehicle Systems

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that the project team had a strong approach that started with detailed physics-based modeling to show which HD and MD vehicle accessory components and which duty cycles would benefit most from accessory electrification. The reviewer added that modeling results are verified through HIL testing. System performance will be optimized and measured (and compared to a baseline system) through full system testing on a dynamometer test cell. Also, the reviewer said that from 2014 to 2015, emphasis appears to have shifted from component testing to on-road system testing in a vehicle. The reviewer asked if this change was requested or approved by the VTO.

Reviewer 2:

The reviewer indicated that the project needs to consider some other critical barriers including costs and weight of the developed system. Also, the project needs to address human behavior (i.e., driver) for better understanding of hotel use.

Reviewer 3:

The reviewer commented that this project contributes to overcoming most barriers. The capability being developed can enable overcoming the barriers if used to identify cost effective alternative accessory drive system designs. The reviewer stated that it is not clear how this project overcomes the cost barrier, perhaps by avoiding new design solutions that do not provide adequate benefits.

Reviewer 4:

The reviewer pointed out that the trade-off of cost/weight on line-haul economics of both conventional and proposed system should be taken into account to show whether it is a significant factor when considering the objective of reducing GHG emissions.

Reviewer 5:

The reviewer said that this review was presented by a person other than the PI (Mr. Deter). It is a multi-year project and it should be noted to all PIs with multiyear projects that the reviewers are different so the original purpose of the project should be restated. Specifically, the reviewer added what Cummins' objective was in pursuing a CRADA. This needs to be clearly stated so that the outcomes could be assessed against the intended purposes of the CRADA.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer stated that since last year, two milestones have been completed and two others have been started. The physics-based accessory models appear to have additional detail over last year. The reviewer added that the 2014 and 2015 slides both show (apparently the same) data indicating that for HD line haul trucks, electrification of accessories for anti-idle hotel load needs is a more effective application than powertrain hybridization. The reviewer concurs, but unless this project has produced substantially higher-fidelity data in support of this conclusion, this is not a new finding. The Proposed Sleeper Cab Idle Mitigation no longer includes connectivity with shore power, engine start/stop capability, or traction assists to the engine. The reviewer also said Integration of NREL's Cool Sim Model, Conventional Air Conditioning Testing, Electric Air Conditioning Testing, and Prototype Testing and Vehicle Integration were achieved this year. Developed and designed a new prototype system that was first assembled and is being tested in an HIL environment as well as being prepped to be installed in a test vehicle.

Reviewer 2:

The reviewer said that there are significant accomplishments; however, the mitigation plan should think beyond the development of the systems. The project should also consider the economic trade-off between fuel consumption and use, costs and weight of the system.

Reviewer 3:

The reviewer commented that it was hard to understand the technical path and how it intertwined with Cummins' work. By not having the PI present, questions could not clarify the technical work. The reviewer added that there was also no Cummins representative there to support. The reviewer could assume that the work could lead to a positive conclusion but was not sure. Achieving a full system model is a very necessary task to complete for future development of new versions of the accessory drive system. The reviewer added that how well this was done could not be assessed from what was presented.

Reviewer 4:

The reviewer noted that as a tool development project it can enable the overcoming of barriers if applied diligently. It would be helpful to understand the range of truck propulsion and accessory topologies this tool is intended to support. The reviewer added that for a Class 8 line haul this effort seems a bit mismatched. For other truck applications that have several non-mobility based accessory requirements in addition to the traditional accessories, this capability may be more meaningful. The reviewer asked how this model integrates different duty cycles for the vehicle; for the engine; for the engine water pump. Electrified accessories open the door to new accessory duty cycles that could provide an efficiency gain of their own. The reviewer asked if there is a means to operate the accessories differently from how they operate when mechanically coupled to the crankshaft.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer said that the project has good collaboration with partners from industry and national laboratories.

Reviewer 2:
The reviewer reported that collaboration seems appropriate for the scope of the effort.

Reviewer 3:
The reviewer stated that the project team had added a productive collaboration with NREL since last year in response to a reviewer comment as well as collaborations with EMP and Masterflux. The reviewer asked if the collaboration with Meritor that was reported in 2014 has simply run its course, or did it fall apart.

Reviewer 4:
The reviewer pointed out that it is a CRADA so coordination is pre-established.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer stated that there is not much time left in this project timing, so suggested just finishing what was planned, as it makes sense on the surface.

Reviewer 2:
The reviewer commented that the project should consider expanding the future work to other areas.

Reviewer 3:
The reviewer indicated that the proposed future work is to follow through with the project and that this seems appropriate.

Reviewer 4:
The reviewer said that one of the stated 2014 objectives was to “Test the new prototype system on a powertrain in the VSI Powertrain Test Cell.” In 2015 this has been changed to read, “Test the new prototype system in a real world setting on a test vehicle using one of Cummins test trucks.” While real-world data is very important, testing of the prototype system in the VSI Powertrain Test Cell is more controllable and repeatable and should not be shortchanged. The reviewer added that it is good to see the electrified accessory system being baselined against conventional accessories.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer reported that this not only supports DOT objectives, but also the DOT Clean Transportation Sector Initiative goals of 80% GHG emissions reductions by 2050, as well as EPA objectives.

Reviewer 2:
The reviewer remarked that the project has potential for large savings in fuel consumption of HD line-haul trucks.

Reviewer 3:
The reviewer said that because one of the biggest wastes of fuel in line-haul trucks is from accessory loads when resting, as well as when in operation, a new approach to saving fuel due to accessory (hotel) loads will reduce petroleum use.

Reviewer 4:

The reviewer stated that this project is likely to result in electrified accessory systems that reduce or eliminate overnight HD truck idling, resulting in substantial fuel consumption and GHG emission reductions. It will also dramatically reduce local pollutant emissions in areas where truck drivers take their rest periods.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented that the project team appears to be making excellent progress along a productive track. Consider providing additional resources so that the team can also develop HD transit bus accessory systems.

Reviewer 2:

The reviewer stated that this project seems resource-constrained, which may help explain its current narrow focus.

Reviewer 3:

The reviewer pointed out that given the complexity of simulating many components and configurations, optimizing these configurations and then validating on an actual test vehicle, the funding seems to be modest.

Reviewer 4:

The reviewer indicated that the project seems to have sufficient resources to complete as scheduled.

Reviewer 5:

The reviewer said the project has sufficient resources.

Vehicle Thermal Systems Modeling in Simulink: Jason Lustbader (National Renewable Energy Laboratory) - vss134

Presenter

Jason Lustbader, National Renewable Energy Laboratory.

Reviewer Sample Size

A total of four reviewers evaluated this project.

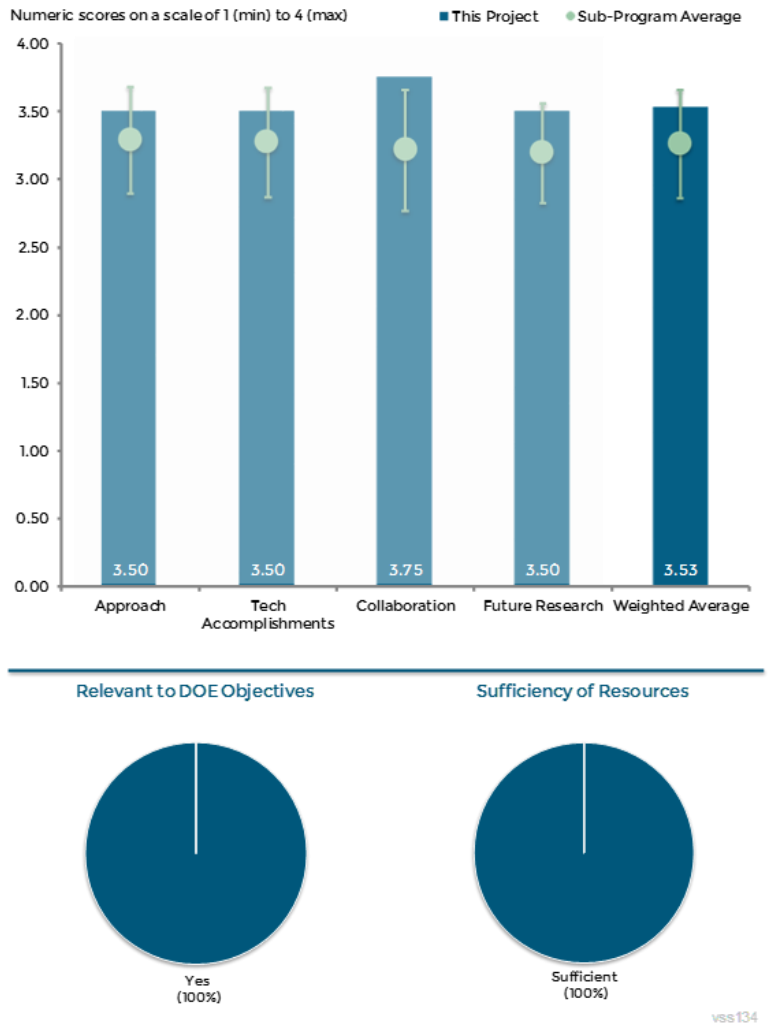


Figure 1-22 Vehicle Thermal Systems Modeling in Simulink: Jason Lustbader (National Renewable Energy Laboratory) - Vehicle Systems

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that there was a very good flow to information and solutions.

Reviewer 2:

The reviewer thought the approach is good and that being able to model the system performance and components accurately is a useful tool, especially if it can be co-simulated with Autonomie.

Reviewer 3:

The reviewer commented that the approach is well done. To the extent that it does not duplicate commercial activities, it provides value.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer reported that the project objectives have been met successfully. There are some inherent limitations on what can be modeled due to the breadth of the available design space, but these have been addressed to the extent possible.

Reviewer 2:

The reviewer indicated that the accomplishments appear in line with the program, although the reviewer would like to see the details behind the vehicle cabin model and whether this can be further optimized.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that the project provides good connections and collaborations with users of the software.

Reviewer 2:

The reviewer pointed out that the collaboration with Tier 1 and an OEM is good to see although the reviewer is not sure that the Daimler Trucks North America (DTNA) participation is actually relevant to this project.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer would like to see this program leverage the Cool Cab HD sleeper program and understand if there are other cooling philosophies that can be applied such as zoning, etc.

Reviewer 2:

The reviewer commented that the plan seems appropriate, in particular the validation steps and proof-of-concept projects with industry partners.

Reviewer 3:

The reviewer noted that the project goal of applying developed Simulink tools with industry partners to look at system tradeoffs in co-simulation with Autonomie has implied requirements on the Autonomie project to maintain and ensure compatibility with NREL's Thermal Model. It is also likely that the Autonomie project will be required to provide some level of support functions to ensure the success of these studies with industry partners. The reviewer asked if there is a commitment by DOE to maintain compatibility of these models and enough support to ensure that this capability will function long enough to provide significant return on investment (e.g., three to five years).

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer believed that small steps in modelling capability will lead to bigger steps in production as we use the tools to better understand our ecosystem.

Reviewer 2:

The reviewer pointed out that this project is filling a gap in the tools needed to address the design of vehicle systems that minimize energy consumption for management of thermal loads. The current generation of light-duty EVs experiences significant range reduction when operating in extreme temperatures. The reviewer added that HD vehicles also consume large amounts of energy performing thermal management functions. This tool provides the light- and heavy-duty R&D communities with capabilities to evaluate concepts with potential to increase EV range (while operating in extreme temperatures) and increase the fuel efficiency of HD vehicles.

Reviewer 3:

The reviewer said that we need to develop pathways to conserve in all sectors.

Reviewer 4:

The reviewer commented that this addresses the design of non-propulsion systems that represent parasitic loads that consume fuel energy. The project also enables study of design improvements that lead to more efficient systems

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that the resources appear to be adequate.

Advanced Climate Control and Vehicle Preconditioning: John Meyer (Halla Visteon) - vss135

Presenter

Heido Crandall, Halla Visteon.

Reviewer Sample Size

A total of four reviewers evaluated this project.

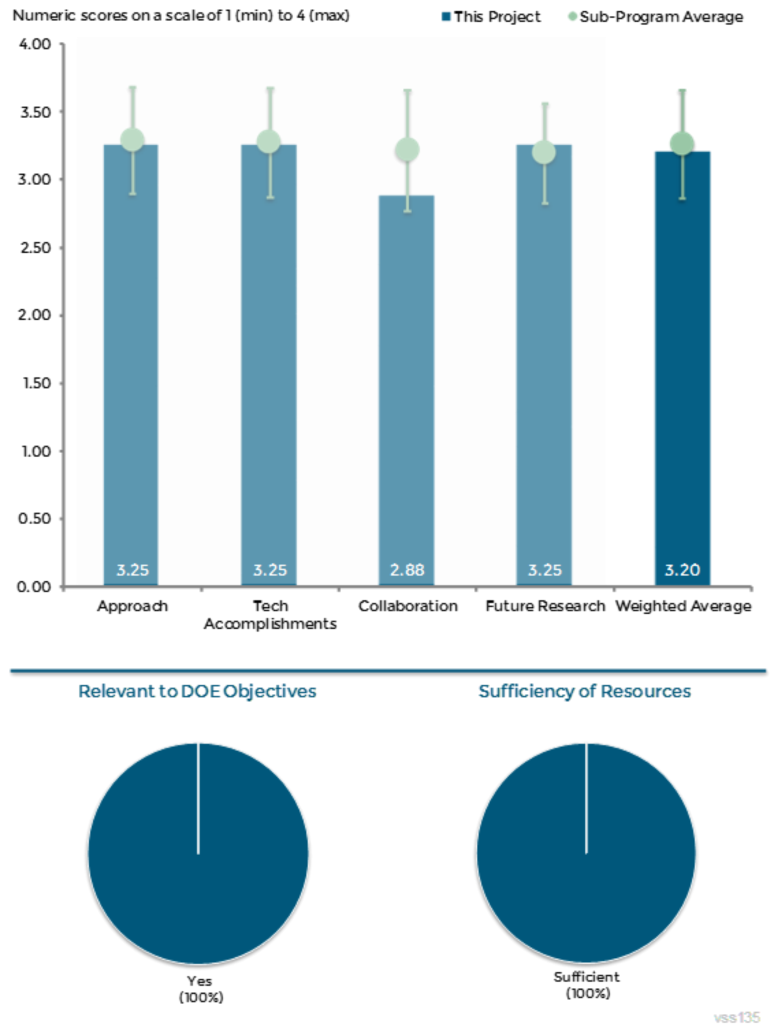


Figure 1-23 Advanced Climate Control and Vehicle Preconditioning: John Meyer (Halla Visteon) - Vehicle Systems

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer reported a good basic timeline and progress from modeling through hardware and integration and testing, and a wide range of ambient temperatures in the project scope.

Reviewer 2:

The reviewer stated that the three-tier approach from analysis to design to demonstration is appropriate.

Reviewer 3:

The reviewer commented that gaining electric range without driver discomfort is certainly important in view of the present state and cost structure of lithium-ion (Li-ion) batteries. May benefit the analysis to including drive cycles off-grid origin. For example, the reviewer cited outdoor parking in peak winter or summer temps. This will bring into the analysis optimization of the HVAC in more realistic conditions and not only pre-conditioning for range extension. The reviewer also said how the calculations for energy use have been made, pre-conditioning reduces overall efficiencies.

Reviewer 4:

The reviewer indicated that the Halla Visteon Advanced Climate Systems for EV Extended Range project is focused on developing advanced HVAC systems to reduce the impact of climate control loads in PEVs and thereby extend vehicular range. The project utilizes a combination of modeling and testing to identify, verify, and prioritize load reduction opportunities and solutions while maintaining passenger comfort. The reviewer added that several key areas are being considered including cabin pre-conditioning, thermal energy storage, refrigerant system efficiencies, and perceived comfort control and zonal strategies. The approach incorporates a classic phased strategy of subsystem design and specification development; design, fabrication, and validation; and integration and vehicle validation. The reviewer also commented that a model year (MY) 2015 Kia Soul EV with a heat pump and positive temperature coefficient (PTC) heater options has been selected as the test vehicle. One question comes to mind, the reviewer said, asking if any passive load reduction elements are being considered as part of this project such as solar glazing, reflective paint, cab insulation, etc. If not, it may be good to consider them, as it could lower the overall requirements on the advanced HVAC systems, making them more technically and economically viable.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer noted a number of demonstrated accomplishments including the establishment of performance targets for vehicle test range improvement at six target temperatures (cold to hot); several vehicle-level evaluations in cold, hot, and wind tunnel conditions; wind tunnel evaluation identifying overconsumption as a potentially large energy savings opportunity; potential benefits from driveline thermal storage have been established; a variety of systems, modelling, and correlation activities have been conducted; as well as development of improved refrigerant and coolant loop architecture designs. The reviewer added that the revised refrigerant loop configuration appears to be a simplification likely to lower the cost of the system, while the revised coolant loop adds a component (battery) likely to increase overall costs. In summary, the reviewer said, these technical accomplishments have demonstrated respectable progress toward achieving the range extension performance targets established by the project. The progress currently achieved is most prevalent at the colder operating temperatures, while continued improvement is clearly needed for the moderate and high ambient temperature conditions. The reviewer also stated that the project has presented potential (although vague) solutions to these challenges.

Reviewer 2:

The reviewer commented that this is a very well-structured and necessary analysis that will need publication. It explores the optimization of HVAC in EV space with range and comfort as control variables. The reviewer said, as stated previously, this needs to be completed with non-grid-connected optimization systems and baseline.

Reviewer 3:

The reviewer stated that the progress is on schedule.

Reviewer 4:

While the reviewer understands the importance of vehicle selection, the reviewer was not sure if this would be considered a technical accomplishment, unless the plan included vehicle architecture; the additional testing to identify areas of opportunity for HVAC efficiency gains was far more interesting and impressive. The modeling correlation/validation established a high level of confidence in the project progress thus far.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer commented that a good selection of partners, assuring proper harvesting of available heat, and estimation of the HVAC system improvements.

Reviewer 2:

The reviewer indicated that the project team consists basically of Halla Visteon, Hyundai America Technical Center, and NREL, not a broad team but one that covers all the required aspects from modeling, testing, technology development, through vehicle integration and evaluation up the chain. In other words, a lean team with the required basic elements. As mentioned, the reviewer said Hyundai's participation throughout will help maintain a focus on value not just performance, which is key for ultimate acceptance into the marketplace. It may be good to consider an additional HVAC systems technology developer for the team, especially if the challenges currently facing achievement of performance targets at moderate and high temperatures prove to be particularly stubborn.

Reviewer 3:

The reviewer stated that this would clearly be improved researching multiple OEMs and varied battery cooling strategies. The reviewer believed there is too much implied commercial system development within this project.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that at a high level, future work is sufficiently well-detailed and sequenced for the rest of FY 2015 and early FY 2016. It would have been good to provide some information on future work through FY 2016. The reviewer added that some elucidation of the key barriers/challenges and the potential options for solving/mitigating them has been provided, although additional insight and detail would be beneficial.

Reviewer 2:

The reviewer pointed out that integrating the heat storage tech will be critical in demonstrating in vehicle cold temperature range extension.

Reviewer 3:

The reviewer noted that plans for advanced consideration of energy storage systems (ESS) coolant integration is a good plan, comfort modeling in extreme ambient conditions would be valuable and is also planned. Evaluation on standard drive cycles would be valuable for comparison and contrast to other systems and costs and benefits.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer pointed out that clearly the alignment with DOE goals was in the presentation and highlighted benefits of project success.

Reviewer 2:

The reviewer stated that EV range reduction in cold weather is significant. Addressing this use for real-world concerns is critical. The reviewer added that developing and demonstrating this technology is also critical.

Reviewer 3:

The reviewer commented that this project supports the overall DOE objective of petroleum displacement as development of advanced climate control systems for PEVs will lower auxiliary load requirements on the vehicle, thereby increasing vehicle range and improving consumer acceptance.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that this project is 50/50 cost shared. Resources for the project are sufficient.

Electric Phase Change Material Assisted Thermal Heating System (ePATHS): Mingyu Wang (Delphi Automotive Systems, LLC) – vss136

Presenter

Mingyu Wang, Delphi Automotive Systems, LLC.

Reviewer Sample Size

A total of three reviewers evaluated this project.

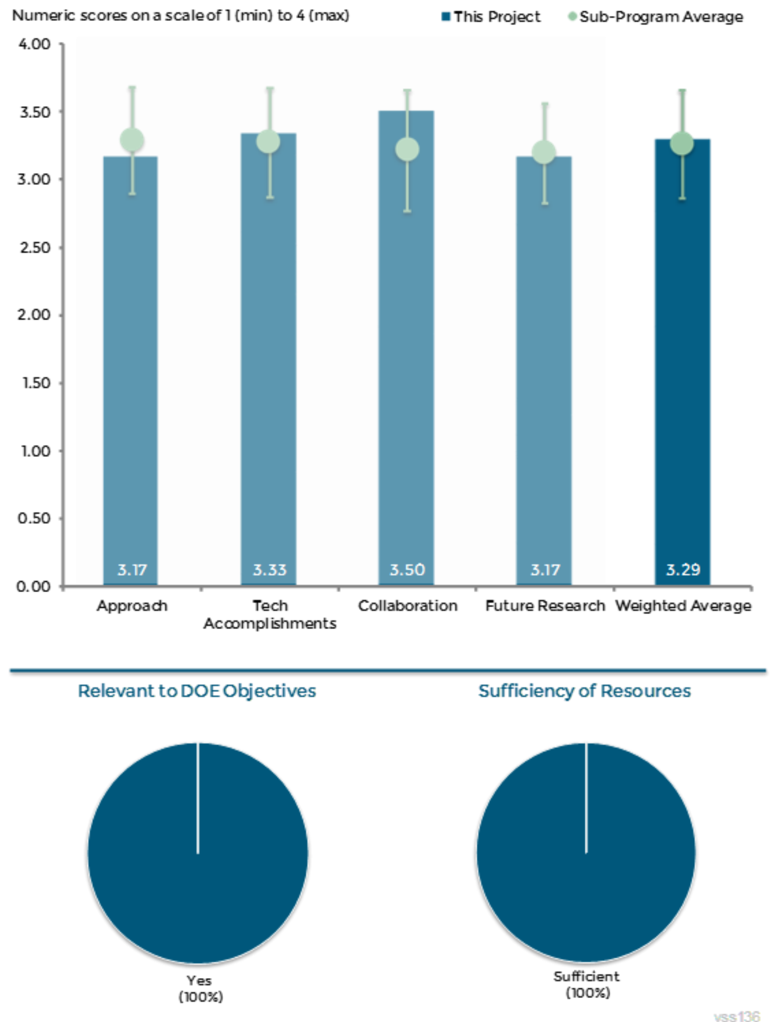


Figure 1-24 Electric Phase Change Material Assisted Thermal Heating System (ePATHS): Mingyu Wang (Delphi Automotive Systems, LLC) - Vehicle Systems

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that the investigation, design, implementation with go/no-go gates is a proper approach. On schedule, design complete for bench testing prior to in-vehicle demonstration.

Reviewer 2:

The reviewer commented that this is a new look at an old technology that will benefit from some new optimization. The reviewer still has interest in off-grid soak time versus effectiveness for this type of technology, and how this will affect thermal battery management. The reviewer asked if there will be a durability side effect.

Reviewer 3:

The reviewer reported that the approach seems feasible and uses standard industry tests. It would be useful to show sizing and heating demographics needed and where the system will or will not work (or what size systems would be needed for various temperatures/humidity levels). The reviewer added that extended soak requirements might be needed to accommodate periods where a vehicle is not parked in garage (and plugged in) and how long thermal storage could last. In these cases, a comparison of grid energy required to heat phase change material (PCM) versus battery energy required to heat and/or maintain PCM would be useful, especially as it compares to the baseline battery heating system.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer pointed out that the project team is on target to date. The design and initial packaging are complete, three heaters have been tested on bench. The reviewer added that two PCM materials are now being considered, working on manufacturing process for such a material.

Reviewer 2:

The reviewer stated that there was good progress through budget period one with design and PCM selected and modeled. Further integration work and vehicle-level validation; will be interesting to see in budget periods two and three.

Reviewer 3:

The reviewer believed that this project is a bit narrow in scope when compared to the entire issue.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer commented that the industry collaboration is good with a vehicle OEM, PCM supplier and system supplier. The reviewer suggested the project should also consider another OEM partner to acknowledge any other design requirements.

Reviewer 2:

The reviewer believed that good partners were selected for expected project scope.

Reviewer 3:

The reviewer said that there was a proper blend of industry and suppliers to demonstrate the 20% improvement of EV range in cold temperatures.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer remarked that the project team was on track to demonstrate technology.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer commented that EV-Everywhere will require vehicles to deliver expectations to the customer per range. Addressing the heating concerns in cold temperature is essential; this project addresses this.

Reviewer 2:

The reviewer reported that this project will further enable EV deployment by lowering cost and/or improving range

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

No comments were received in response to this question.

Impacts of Advanced Combustion Engines: Scott Curran (Oak Ridge National Laboratory) - vss140

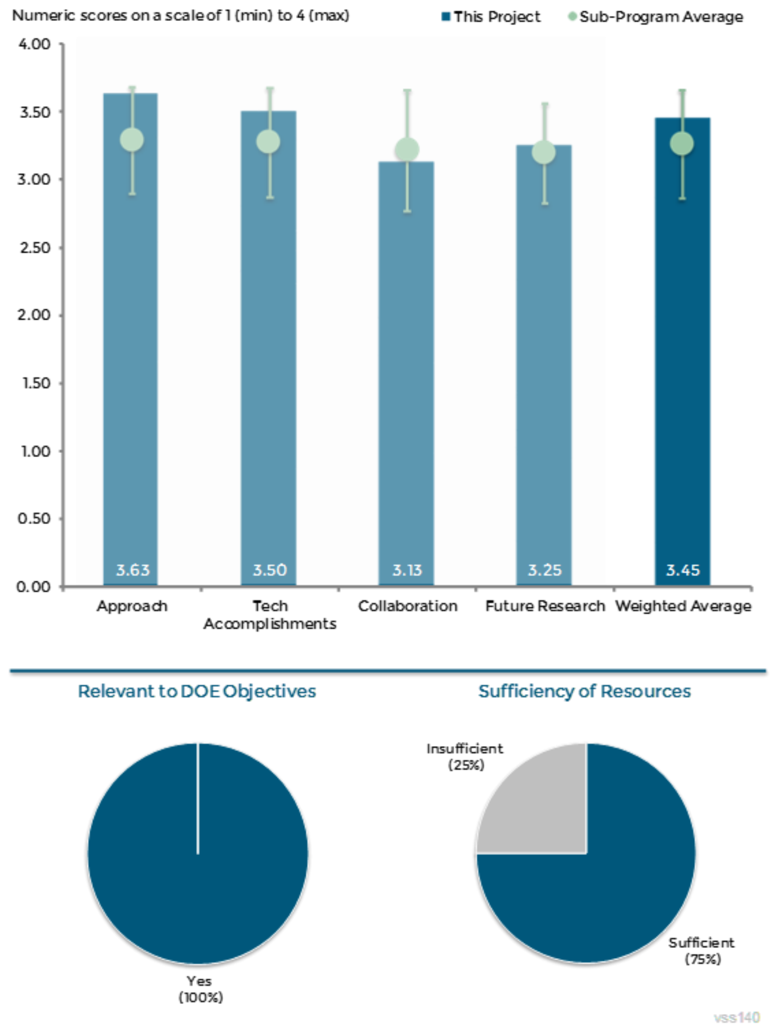


Figure 1-25 - Impacts of Advanced Combustion Engines: Scott Curran (Oak Ridge National Laboratory) -Vehicle Systems

Presenter

Scott Curran, Oak Ridge National Laboratory.

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that the investigation of advanced combustion technology using system simulation with engine efficiency and emissions map generated in an engine test cell provide the most valuable input to the development of new engine technology. If transient engine maps are made available, this research will be able to help industry to develop the after-treatment system.

Reviewer 2:

The reviewer cited a solid approach in this rather short-term project, with good progress to date.

Reviewer 3:

The reviewer commented that the approach using steady-state (SS) maps is a good start, but will only go so far. Transients are the biggest hurdle that need to be overcome, especially when mode transitions are concerned. The reviewer thought that the technologies associated with aftertreatment have not been fully understood and this reviewer’s recommendation would be to pursue an aftertreatment Tier 1 partner or at least someone who can assist in modelling and providing guidance on where this technology is going.

Reviewer 4:

The reviewer indicated that the research is structured well and focuses on understanding in-vehicle benefits of a new combustion regime, based on operating points found in representative drive cycles. This work is deeply integrated with complementary efforts in combustion. The reviewer added that one weakness that should be better acknowledged in the research is the use of SS engine maps in a transient vehicle simulation. Some discussion to highlight the shortcoming of this approach, based on what is known about reactivity controlled compression ignition (RCCI) transient behavior, would be welcome.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer indicated that the project team appears to be achieving the goals of the project.

Reviewer 2:

The reviewer commented that the results achieved help to overcome the critical barrier.

Reviewer 3:

The reviewer reported that a significant amount of simulation results has been generated, given the modest budget. The results of this work benefit continued combustion research, particularly the need to develop controls for mode switching between conventional diesel combustion (CDC) and RCCI. The reviewer added that the project needs to get more clarification regarding hybrid RCCI versus conventional fuel economy improvement. If this comparison is true, they are essentially combined RCCI/hybrid benefits, which makes it difficult to separate out the benefits.

Reviewer 4:

The reviewer stated that the program appears to be on track but the reviewer did not think the full impacts of temperature and the aftertreatment system have been fully understood. For efficient conversion the aftertreatment needs heat and lots of it. The reviewer added that the results so far look good on the combustion side, but the final tailpipe numbers will not be what is needed unless the AT system is converting efficiently.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that the collaboration with ANL and the other research team is very good. The research team should also consider collaboration with universities, which will make the resource available to young graduate students to better understand the importance of vehicle simulation in the development of new engine technologies.

Reviewer 2:

The reviewer reported a great list of partners, but expressed skepticism of programs that do not highlight specific examples of the help from and output to key collaborators. The reviewer suggested that the project team share these successes in these reviews.

Reviewer 3:

The reviewer commented that, as previously mentioned, the reviewer would like to see an aftertreatment Tier 1 on the team or involved in the project.

Reviewer 4:

The reviewer indicated that collaboration appears to be more ORNL internal. Would like to see a bit more interaction with external organizations who work on RCCI.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that the project team needs to model the transient responses into the program and concentrate on a good aftertreatment model. Interpolation between points in a steady-state map only goes so far.

Reviewer 2:

The reviewer reported that the PI should report the energy consumed in RCCI operation, CDC, and other traditional engine operation. The energy saving resulting from replacement of traditional engine operation by RCCI should be specifically reported.

Reviewer 3:

The reviewer indicated that the future research direction seems appropriate as the simulation activities accompany combustion research. The project team’s continued work on aftertreatment refinement and transient operations would be more relevant to support combustion research than the evaluation of HEVs, PHEVs, etc.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer remarked that the application of new combustion technology will continue to play a major role in improving the efficiency of on-road vehicles.

Reviewer 2:

The reviewer commented that any combustion model that increases brake thermal efficiency (BTE) is in the right direction.

Reviewer 3:

The reviewer said that these engines have relevance, have been studied before and can benefit from these types of investments.

Reviewer 4:

The reviewer said that this is a critical step to determine the fuel efficiency of a technology to evaluate system performance in a vehicle. The efficiency gains measured in a test stand do not translate one-to-one to gains made in-vehicle. The reviewer added that this research helps to clarify vehicle-level gains of the technology.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that the development of transient map, especially after-treatment system, needs more time, efforts, and supplies, especially for the RCCI engines.

Reviewer 2:

The reviewer noted a good amount of output given the modest resources.

Powertrain Controls Optimization for Heavy-Duty Line-Haul Trucks: David Smith (Oak Ridge National Laboratory) - vss141

Presenter

David Smith, Oak Ridge National Laboratory.

Reviewer Sample Size

A total of four reviewers evaluated this project.

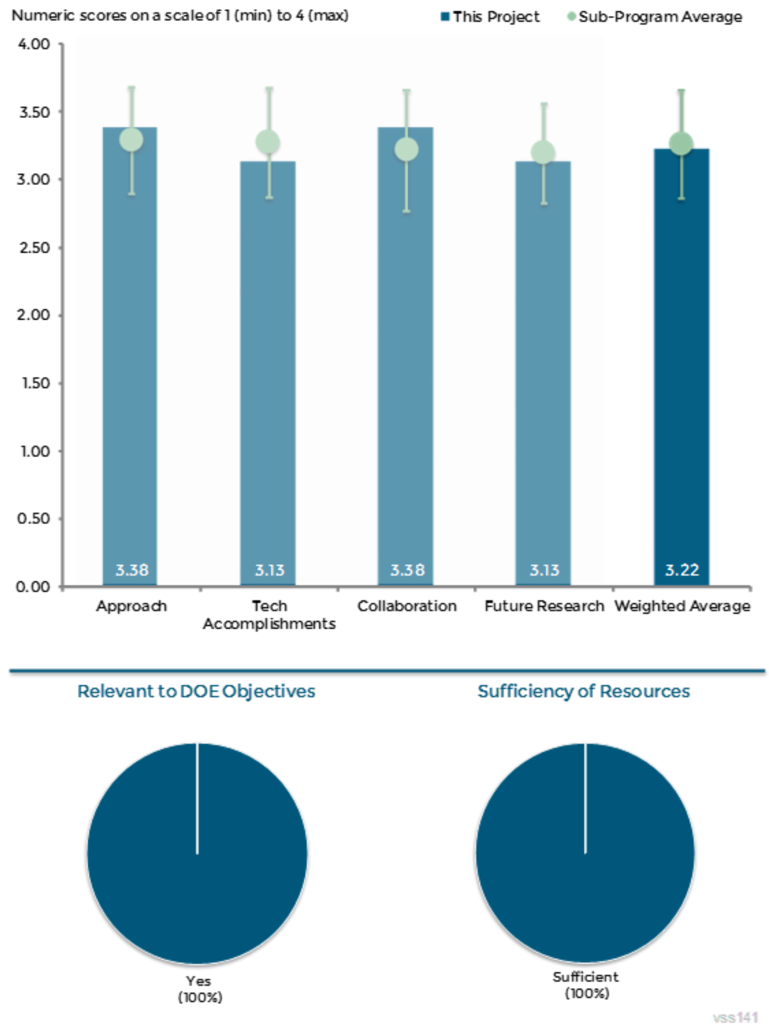


Figure 1-26 Powertrain Controls Optimization for Heavy-Duty Line-Haul Trucks: David Smith (Oak Ridge National Laboratory) - Vehicle Systems

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

It took the reviewer a second reading, but this project addresses a methodical, logical, sound approach to solving a pressing problem in Class 8 cargo haulers. The issue is complex and this project is using what appears to be an excellent combination of simulation and hardware development techniques.

Reviewer 2:

The reviewer stated that the project shows a good approach plan in all areas including modeling, testing, implementation, and system optimization.

Reviewer 3:

The reviewer noted that the project is well structured and leverages test cell data on RCCI and other sources to develop simulation models to evaluate the potential of RCCI in combination with series and parallel hybrid systems. The reviewer would argue the benefits of a parallel hybrid powertrain on line-haul operation is minimal, given the relatively high cruise control usage of the vehicle and low opportunity for regenerative braking. Having a parallel hybrid on board would not significantly affect the operating points of an RCCI engine as opposed to an RCCI engine without a parallel hybrid. However, the reviewer noted a series hybrid powertrain would be different, and potentially more interesting, in that using an RCCI engine with a series hybrid (or range-extended PHEV) has the potential to run the engine in significantly different points on the map, particularly in the low-load range where RCCI is most efficient. The reviewer added that the results from a series or PHEV hybrid configuration would be very interesting.

Reviewer 4:

The reviewer noted that this project overcomes the barriers within one Class 8 truck vocation. The products of this effort could be applied to other Class 8 vocation projects in the future.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer believed that all projects that address freight moving efficiency rate high on the scale of energy savings and reduced oil dependency.

Reviewer 2:

The reviewer stated the project accomplished progress in modeling; however, more work is needed in the engine testing and optimization steps.

Reviewer 3:

The reviewer stated that the modeling approach and results so far look well poised to generate insights into the effectiveness of RCCI with a hybrid powertrain. The ultracapacitor/battery pack benefits will be highly drive-cycle-dependent. The reviewer added that ultracapacitors will be effective to capture energy from short, quick braking. However, on relatively long, steep grades, the ultracapacitor will reach its energy limits and the battery its power limits rather quickly. The reviewer suggested looking into that sort of drive cycle.

Reviewer 4:

The reviewer stated that the project has made good progress toward completion. It is hard to understand the remaining scope and how the test runs of the hybridized system will be conducted. The reviewer asked what the complete scope of the project is and how much experimentation is planned.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted a very good mix of stakeholders and national laboratory talent.

Reviewer 2:

The reviewer stated that the project shows good collaboration with several national laboratories and industry.

Reviewer 3:

The reviewer noted good leveraging of knowledge with other teams in ORNL, ANL and NREL.

Reviewer 4:

The reviewer noted great leveraging of the other capabilities in industry and government. The reviewer asked if the EPA and NHTSA are involved.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that the future plan includes steps for confirming what has been done earlier.

Reviewer 2:

The reviewer believed that the findings on a series hybrid or PHEV variant of the project will be of more interest than a parallel hybrid, given this reviewer’s belief that an RCCI engine will not operate much differently with a parallel hybrid as it would with a series hybrid.

Reviewer 3:

The reviewer believed that it is not fully clear what the final products of this project are. The reviewer asked if it is the capability to conduct component-in-the-Loop (CIL) simulations of a hybrid HD powertrain, or is it to estimate the potential advantage of this architecture, or is it to develop the control strategies for RCCI in a hybridized powertrain.

Question 5: Relevance - Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer noted that it could provide fuel savings.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer believed that project resources are sufficient.

Integration of PEVs with the Grid: Richard Pratt (Pacific Northwest National Laboratory) - vss142

Presenter

Richard Pratt, Pacific Northwest National Laboratory.

Reviewer Sample Size

A total of four reviewers evaluated this project.

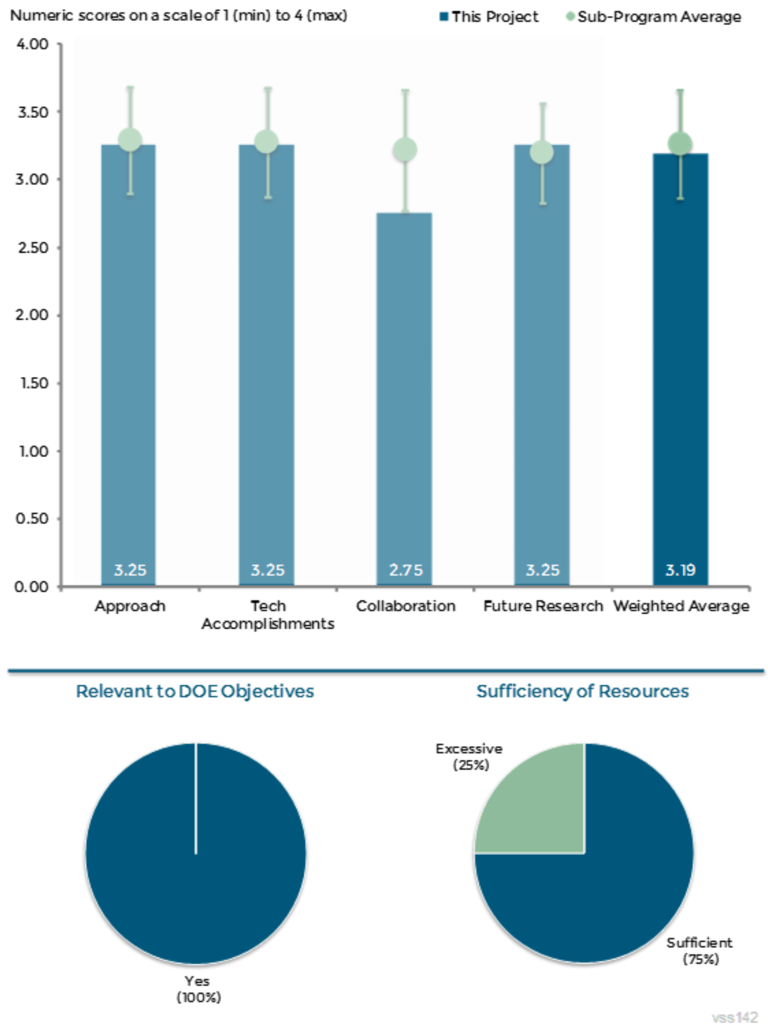


Figure 1-27 Integration of PEVs with the Grid: Richard Pratt (Pacific Northwest National Laboratory) - Vehicle Systems

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer noted a valid technical approach. Results have significant applicability to DOE EV-Everywhere goals.

Reviewer 2:

The reviewer stated that much work has been done on this by others, including utilities, and the reviewer did not see this grounded in any of this other work. The reviewer did not see issues like power factor being addressed. Kilowatt loads can be much higher if feeder power factors are low. The reviewer believed that this seemed too academic and needed more system realities addressed.

Reviewer 3:

The reviewer stated that the overall strategy is to quantify distribution effects from PEV responses to utility tariff structures and explore and emphasize PEV V1G (one-direction charging) economic value while minimizing distribution feeder impact. In short, how to maximize the benefits/lower the costs of EVs to consumers while simultaneously reducing the challenges and enhancing the benefits of EVs to the grid. The reviewer believed that the approach to this project is well thought out, logical, and has a natural economic value to utilities and consumers. At the more detailed level, the approach of modeling PEV / Grid Integration of uncontrolled charging and time-of-use (TOU) charging on distribution feeders and conducting economic value propositions is well delineated with value-added results.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer believed that results are tightly focused on original project objectives. Progress is on schedule.

Reviewer 2:

The reviewer stated that the project has an extensive list of technical accomplishments and results including market and distribution feeder simulation results and systems-level observations. A broad and significant level of technical results have been achieved, providing useful information for utilities, consumers, OEMs, and standards definition organizations (SDOs). The reviewer noted that these results are currently useful to utilities and consumers as well as looking over the horizon to potential issues/opportunities in the future. The reviewer added that some of particular interest include knowledge that not all combinations of grid services are compatible (i.e., demand response and time-of-use rates), quantification of feeder limitations when vehicular battery capacities increase (and subsequent charging rates and times increase), and that uncontrolled and time of use charging on moderately loaded feeders can exceed distribution transformer limits. Furthermore, the addition of use cases to the project and specific insights on control and communication requirements is a value add.

Reviewer 3:

The reviewer believed that while the analysis appears rigorous, it is not clear how useful the results are across various actual grid conditions. The assumptions appear the ideal case and may not be applicable in other real-world situations. The reviewer stated that the analysis appears good, but the assumptions and conclusions weak.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that work with INL to obtain EV project data was critical to the credibility of results

Reviewer 2:

The reviewer stated that overall, the level of collaboration and coordination with other entities is acceptable. However, the reviewer would like to echo the comments from other reviewers last year indicating that an increased level of collaboration with utilities, EVSE manufacturers, SDOs, and other entities would be beneficial, including the NREL INTEGRATE project.

Reviewer 3:

The reviewer said that it did not appear that much interaction had taken place with utilities who are actually facing this issue in real time like San Diego Gas & Electric (SDG&E). Some utilities have done their own analysis and it was not clear this was reviewed or considered. The reviewer added that other labs have also done similar analyses that was not referenced.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer noted that the project is nearing completion. Future projects should consider workplace charging and the integration of lessons learned from this project into the overall.

Reviewer 2:

The reviewer stated that lab modelling efforts are important but need to be more clearly guided by real industry situations and problems. Maybe an industry advisory group would add some strategic value.

Reviewer 3:

The reviewer stated that the proposed future research is very well documented and detailed. It provides a clear sense of where the project would like to go and expected outputs covering a number of important areas including additional simulation quantifying potential PEV market value and renewable integration, as well as communication and technology requirements to support value-optimized use cases. The reviewer noted that communication and control technology hardware and standards hardware are also proposed to be addressed. Additionally, as part of the path forward, three research areas are clearly identified and reinforced through the multi-lab collaborative, namely simulation, emulation, and hardware.

Question 5: Relevance - Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that this project is relevant to DOE objectives of petroleum displacement as it offers specific results and prognostication in maximizing the value proposition of EVs while minimizing or even enhancing their value with respect to the grid. In this way, it is likely to help further consumer acceptance of EVs while mitigating infrastructure challenges.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that resources for this project are sufficient.

Reviewer 2:

The reviewer believed it was hard to determine the relevant cost/value for this project. Modelling is important and can be expensive, but modelling for modelling’s sake is not a high priority.

Powertrain Codes and Standards Development: Mike Duoba (Argonne National Laboratory) - vss143

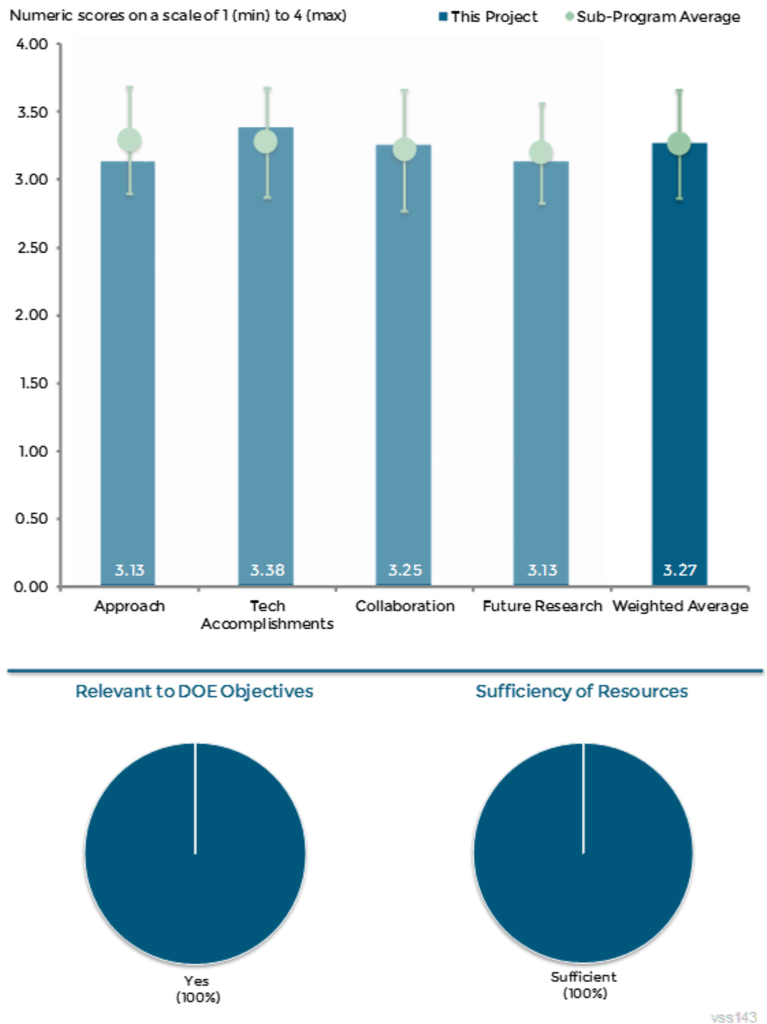


Figure 1-28 Powertrain Codes and Standards Development: Mike Duoba (Argonne National Laboratory) - Vehicle Systems

Presenter

Mike Duoba, Argonne National Laboratory.

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer noted excellent use of existing resources and partnerships with relevant industry and government partners.

Reviewer 2:

The review believed that the approach taken will provide a path forward to a common test standard.

Reviewer 3:

The reviewer stated that consideration of how consumers might use a hybrid system in the real world would seem to be very useful in this work. The rating of the system will depend heavily on the test cycle or condition used to determine the rating. The reviewer continued that if the test does not correlate with real-world usage, the rating will not be very useful. The reviewer added that evaluations of hybrid powertrains has suffered from this problem in the past. Fuel economy test cycles that are acceptable for a conventional powertrain (FTP75, etc.), often do not give results that match real-world operation. The adjustments made by EPA to address this issue are evidence of this challenge. The reviewer stated that although it is clearly a very challenging issue, it seems it would be worthwhile to make an attempt to define some test protocols that would correlate with customer usage. Industry partners may be able to help.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer believed the project has made a big impact on automotive electrification standards. It provides independent authority that industry respects.

Reviewer 2:
The reviewer stated that the example provided comparing a Prius to a Sonata is acceptable, and would like to see a comparison of multiple tests on the same vehicle.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer stated that all of the appropriate stakeholders appear to be accounted for in this project.

Reviewer 2:
The reviewer stated that the collaboration seems reasonable. One potential opportunity that was not mentioned is collaboration with the SAE J2711 working group. The reviewer added that this is the HD version of the hybrid test procedure for passenger cars (J1711). This working group focused primarily on chassis dyno testing, but has considered additional work that would focus on powertrain testing. The lead for the group is Paul Chambon at ORNL, but the reviewer was not sure of the current status.

Reviewer 3:
The reviewer noted that having the OEMs' support with their vehicles will provide vehicle selection and additional test data.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer recommended expanding the number of vehicles tested, with support from OEMs. The will drive acceptances from the OEMs for a new way of testing that could result in a new rating system.

Reviewer 2:
The reviewer believed the project take necessary steps to finalize the project objectives.

Question 5: Relevance - Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer stated that a better definition of hybrid power ratings would be very useful to consumers as well as industry, and a transparent methodology could help consumers better understand hybrid system capability and allow them to make good decisions in purchasing hybrid products.

Reviewer 2:
The reviewer stated that the project addresses consumer information gaps in comparing conventional and hybrid vehicles. Helps to demystify hybrid vehicles.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

No comments were received in response to this question.

Green Racing Protocols and Technology Applications: Perry Jones (Oak Ridge National Laboratory) - vss144

Presenter

Perry Jones, Oak Ridge National Laboratory.

Reviewer Sample Size

A total of five reviewers evaluated this project.

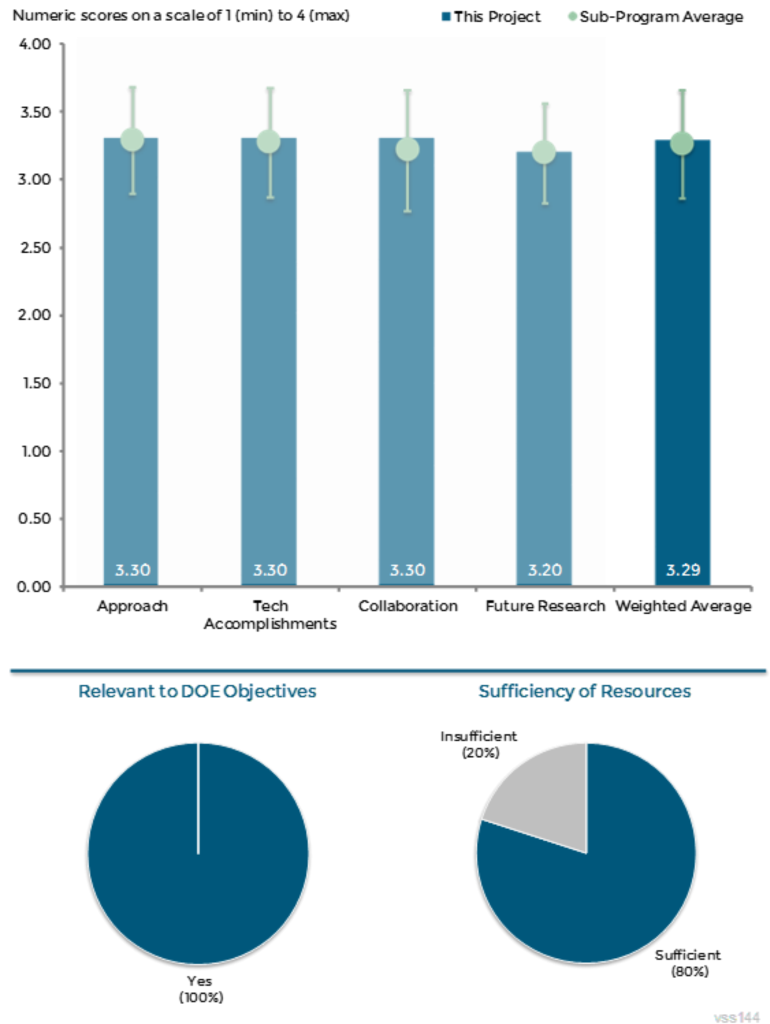


Figure 1-29 Green Racing Protocols and Technology Applications: Perry Jones (Oak Ridge National Laboratory) - Vehicle Systems

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that the objectives and relevance were well illustrated. The reviewer believed the approach was slightly weak; the reason of the delay of six months by Dyson was not explained except to say they will recover, without explaining how. The Green Racing Simulator served a good purpose to help explain the advanced technology

Reviewer 2:

The reviewer stated that as an intensely competitive activity, racing inherently encourages teams of creative, motivated people to develop and implement practical solutions in the shortest possible time. The reviewer added that racing provides a means for widely publicized demonstration and rigorous testing of new technologies. As a spectator sport, racing makes these innovations highly visible to a fan base that disproportionately includes technology early adopters. The reviewer suggested that because of the involvement of multiple sponsors, racing also results in significant leveraging of DOE's investments. The project is trying to show the link to consumer vehicles – Win on Sunday, sell on Monday. The reviewer noted that assignment of green racing points based on technologies used and results achieved seems to be working effectively. What would really be convincing is for an alternatively fueled race car to beat a conventionally fueled race car head-to-head (e.g., by taking advantage of greater effective octane).

Reviewer 3:

The reviewer indicated that this project seems to be an attempt to get sanctioning bodies of major racing series to implement and promote the use of non-fossil fuels. That, in and of itself, is in line with the objectives of DOE to displace petroleum fuels. The reviewer emphasized that racing bodies are economically driven entities who will implement change to improve their economic state. Seldom do they do anything for any other reason. The reviewer believed that the promotion of non-fossil fuels and energy efficiency can help these race series by promoting themselves as responsible citizens; making the events more sustainable. Promoting them as such opens the door to fans that may be heretofore unreachable due to what they perceived as wasteful use of resources. The reviewer stated that the added effect of having large fan groups see their entertainment medium moving to a sustainable technology can start to validate the technology for use in their personal transportation. To see change takes the fear out of change. Regarding the presentation, the reviewer noted a couple of definitions could have made it easier to understand the project. Namely, what is the definition of Green Racing and what is the reasoning for the development of the protocols?

Reviewer 4:

The reviewer stated that the overall concept of leveraging and increasing awareness/acceptance of advanced vehicular technologies and fuels through motor sports is unique and has merit. The reviewer added that Green Racing provides a venue to trial test and showcase these technologies and can serve as a gateway to introducing them into consumer vehicles, which indeed has been the case in several instances. The approach of establishing industry-recognized Green Racing Protocols through SAE is sound and will provide a clearer and defensible mechanism for objective recognition levels. The reviewer added that efforts to introduce cellulosic ethanol into International Motor Sports Association (IMSA) will expand visibility for biofuels, which often face unique challenges. The reviewer indicated one thing that is not completely clear and questioned exactly how these Green Racing recognition levels will be utilized. The reviewer asked whether teams that achieve a certain number of points (based on the Recommended Green Racing Protocols) will be given an award or recognition of some sort, or is it possible to conceptualize a method whereby the team's final placement in races would be a combination of actual racing times and their level of Green Racing Protocol achievement. In other words, the reviewer asked if there are additional innovative ways to combine the Green Racing Protocols and the actual racing times to develop a hybrid scoring approach that may entice broader participation and involvement.

Reviewer 5:

The reviewer stated that the goal is admirable, but the ultimate success of the project depends on the linkage between improved consumer acceptance of green vehicle technology and green racing that seems difficult to test.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer indicated that the accomplishments meet the objectives of the program. The SAE Standard is a good step. The tie-in with IMSA is also excellent.

Reviewer 2:

The reviewer believed that the approach to have protocols and standards is critical. The reviewer likes to see how the generation and agreement process of the protocols is being achieved.

Reviewer 3:

The reviewer noted the publication of revised SAE Recommended Practice J2880, "Recommended Green Racing Protocols." Early green racing protocols were more subjective; the new protocols are more objective. The reviewer mentioned an established memorandum of understanding (MOU) with IMSA. Green Racing Simulator has returned to outreach activities. The reviewer stated that over 4,000 people have driven the Green Racing Simulator, which is not only entertaining but educational as well. The reviewer stated a supply of cellulosic ethanol (E85) has been arranged. NASCAR has received 500,000 hits on its E15 page (it was not clear how many of those hits are directly attributable to this project). The reviewer indicated that no milestone chart was provided; just a short table.

Reviewer 4:

The reviewer stated that the technical accomplishments have been solid including the successful balloting of revised SAE J2880 "Recommended Green Racing Protocols" and establishment of objective new recognition levels, introduction of cellulosic ethanol supply for IMSA, reintroduction of the Green Racing Simulator, and the re-launch of GreenRacingCup.org. The reviewer believed it is definitely important to push hard to expand the Green Racing Partnership to include new sanctioning bodies and try to further expand the reach of Green Racing. Additionally, the reviewer asked if there is a way to establish a system to measure the success/growth rate of introducing new technologies/partnerships through Green Racing. For example, it is somewhat difficult to gauge whether the progress of Green Racing has remained steady, been on an upward growth trajectory, or declined in its value proposition over the last several years. If there was a process/or more information to assess, this it would be beneficial.

Reviewer 5:

The reviewer stated that the completion of the protocols constitutes a significant advance. It creates a step-by-step progression to a race series becoming environmentally sustainable. The reviewer believed that certain questions remain though and asked how sanctioning bodies are convinced to use the protocols, and whether they were involved in their development and in how to apply them. Regarding technologies other than fuels, the economic constraints in racing can limit the application of these new sub-systems. The reviewer noted that it seems that a major partner (like an auto company or interested supplier) would have to be involved for widespread application to offset the development costs. This is more difficult nowadays because the development processes for new hardware are much faster and computer-based, whereas in the past racing was more widely used for initial concept prove-out when development was empirical. The reviewer believed that alternative fuel uses would be easier to implement than allowing expensive concept technologies in this era.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that overall, the project has a good breadth of collaboration including IMSA, EPA, SAE, and ANL, with each taking on different roles. There are no large gaps here, although it would be good to increase collaboration with other motors sports associations/authorities to widen and deepen the commitment to Green Racing. The reviewer believed it may also be beneficial to explore additional communication strategies and further expand media support and outreach through additional entities besides just EPA.

Reviewer 2:

The reviewer mentioned the MOU with IMSA. The reviewer stated getting assistance from ANL on the website and with the Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) well-to-wheels modeling. The reviewer indicated collaborating with EPA (including on-site support at races) and SAE. Partnering with Harvard Kennedy School Belfer Center, Motorsport Engineering Conference, CAPE, and Purdue University. Interestingly, the project team is not working with Formula-E. The project team said it is because the rules of that series do not allow enough innovation. The reviewer recommended the team explore changing this situation.

Reviewer 3:

The reviewer questioned how the different collaboration partners are engaged to help leverage an agreement on protocols and standards. In addition, the reviewer asked if there are any opportunities to involve the OEMs with this activity so they can learn and participate toward a production path.

Reviewer 4:

The reviewer indicated many collaborations with the major players in racing are in place or in development. Without this there is no chance of implementing change. The reviewer added that while budget constraints are clear, under no circumstances would DOE ever become a team sponsor. But there is no reason why good, technically competent teams could not form CRADA with DOE units (or laboratories) to leverage the pot of knowledge in that broad technology system. The reviewer believed it would be a good idea to try to do just one of these in the next year to see how it can work.

Reviewer 5:

The reviewer said that it is not for lack of trying, but the absence of NASCAR as a partner hurts the main aim of the project.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer stated extends the current work in an appropriate way.

Reviewer 2:
The reviewer stated that the team is working to develop partnerships with two additional race sanctioning organizations. An audience member suggested that the Green Racing Program reach out to better involve small and mid-sized teams.

Reviewer 3:
The reviewer noted that while funding limits the effectiveness of the effort, it has had good success. Keeping in mind that this is a great outreach project and could open the door for some limited future technical collaborations, the effort must continue; stopping it may create a reversion to a past condition. The reviewer believed it is funny how racing has so many players that enter for a short time, create a stir and then disappear. Their impact is often discarded and forgotten. The reviewer indicated that the emphasis should be on broadening the number of wins. Getting some substitute fuel that other levels in racing can drop in would be incredibly profound and make an incredible impact. Recommend exploring how and whether this can be pursued.

Reviewer 4:
The reviewer stated that the proposed future research is reasonable, covering a lot of ground. The reviewer recommended focusing especially hard on the completion of agreement for additional racing series into Green Racing framework and International series recognition for North American events performed in alignment with J2880. The reviewer also strongly recommended bringing into the fold new sanctioning bodies and racing partners. This is especially important as the project ends in September 2016 and a strategy for Green Racing to become self-sustaining needs to be identified and established.

Question 5: Relevance - Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer noted that alternative fuels in racing vehicles directly substitute for petroleum fuels. Far more important, racing pushes alternative fuel technology, demonstrates the performance and reliability potential of alternative fuels, and builds awareness. All of these can lower barriers to introduction of alternative fuels by industry, and adoption of alternative fuels by users.

Reviewer 2:
The reviewer said the project advances use of alternative fuels in racing and hopefully increases consumer awareness.

Reviewer 3:
The reviewer indicated that the technologies being implemented or in use either substitute fuels or find ways to save fuel. That displaces petroleum.

Reviewer 4:
The reviewer stated that Green Racing supports DOE objectives of petroleum displacement by encouraging the implementation of advanced, efficient vehicular technologies and fuels into racing to enable technology evaluation and visibility to millions of potential vehicle purchasers. Green Racing helps serve as an evaluative transition point for technologies as they potentially make their way toward consumer vehicular applications.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that the team is achieving useful results from the modest funding they are receiving.

Reviewer 2:

The reviewer noted that resources appear to be sufficient.

Reviewer 3:

The reviewer indicated that resources for this project are sufficient.

Reviewer 4:

The reviewer indicated that this is a hard question to answer, but it is certainly not excessive. The project has limited funding which limits the promotion of the technologies broadly and potential application of DOE technical help to implement these petroleum displacing technologies sooner. As they say in racing circles: “speed costs money, how fast do you want to go?” But another old adage says: “Race only where you can afford to win,” so recommend that the resources be focused on the biggest and broadest positive outcomes. The reviewer recommended focusing only on some quantifiable successes in achieving petroleum displacement and also finding a way to promote the effort so that awareness of the gains is more broadly known by race fans.

Technology Requirements for High-Power Applications of Wireless Power Transfer: Omer Onar (Oak Ridge National Laboratory) - vss152

Presenter

Omer Onar, Oak Ridge National Laboratory.

Reviewer Sample Size

A total of four reviewers evaluated this project.

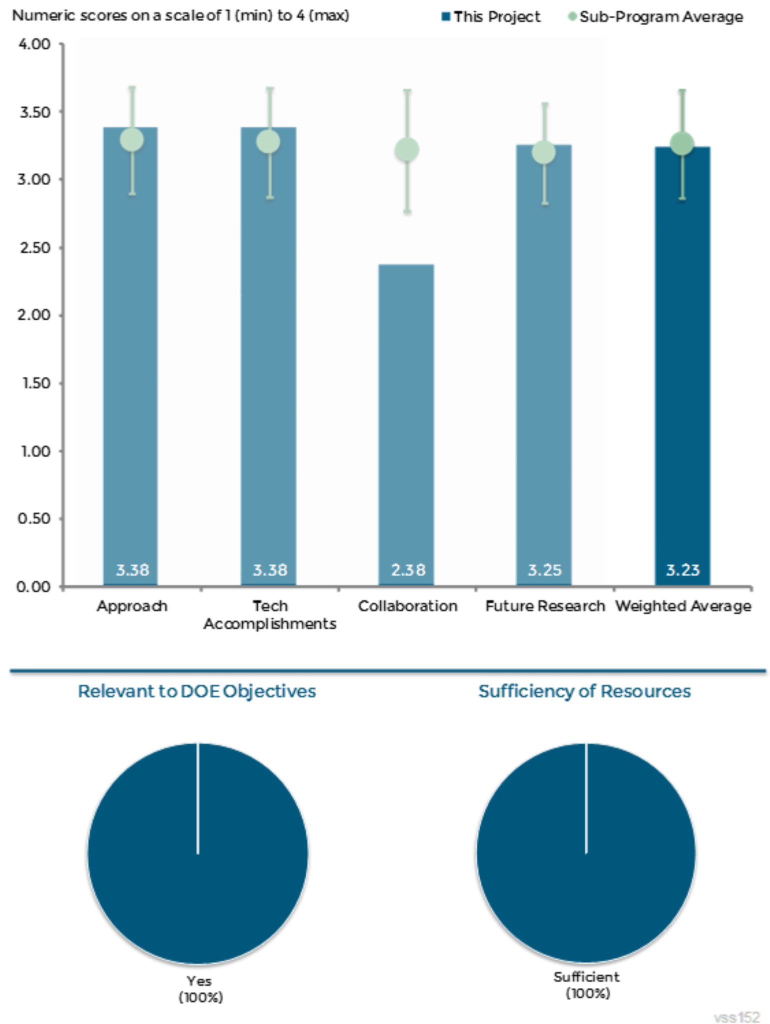


Figure 1-30 Technology Requirements for High-Power Applications of Wireless Power Transfer: Omer Onar (Oak Ridge National Laboratory) - Vehicle Systems

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that the approach taken is in line with the project objectives.

Reviewer 2:

The reviewer stated that the proposed work is well thought out. The reviewer said that it lacks partners that would use this technology. Need clarity on the project milestones/dates.

Reviewer 3:

The reviewer noted that although the objectives are well stated, the scope is not. Therefore, it is unclear if the anticipated application is to buses, light rail or other.

Reviewer 4:

The reviewer believed there needs to be clarification on what actually is part of this currently funded project, and what is aspirational and for future funded projects. The reviewers were all confused about the structure of this project based on the milestone slide. If future work is planned, that should be part of the Future Work slide, not part of the milestones listed for this project. Having said that, if the objective of the project was to produce a model, the project appears to be successful in achieving this objective.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer indicated that the progress made and the technical achievements are in line with the project deliverables.

Reviewer 2:

The reviewer stated that the modeling appears to have evaluated a variety of designs and addressed the performance issues in current high-power wireless power transfer (WPT) designs.

Reviewer 3:

The reviewer stated that the technical work to date is well done. Needs to consider the practicalities of implementing this system. The reviewer questioned whether we want to do all of this technical work if it is not in fact economically practical.

Reviewer 4:

The reviewer stated that the work is sharply focused on system design outside of application environment, without taking into account simulations of effects that the operating environment may have.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer said that partners are needed that would apply this work.

Reviewer 2:

The reviewer noted that although it is understandable that this is still in the design phase, it is advisable to reach out to DOT/transit companies that have a stake in the technology to discuss future ramifications of mutual relevance.

Reviewer 3:

The reviewer indicated that there are no collaborators listed, making the lack of collaborations for this project noticeable. ORNL is no doubt a leader in R&D in this area, but the reviewer wondered if there are no industry collaborators that could be brought into this project. The reviewer asked if there are other research groups working on high-power WPT with which ORNL could collaborate. The reviewer also asked who will provide the integration with the bus in the same way Toyota and Evatran performed the integration in the light-duty vehicle (LDV) WPT system from a previous presentation.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that the steps to building a system once a design has been decided upon seem solid, as does the plan to work with a bus manufacturer to implement the system in an actual vehicle. If the funding comes through, the planning for these stages must be described more explicitly.

Reviewer 2:

The reviewer stated that the future work was not clearly articulated. The reviewer asked whether the project is just starting, or wrapping up.

Reviewer 3:

The reviewer urged consideration of simulation or empirical testing of operating environment variable anticipated in the appropriate application.

Question 5: Relevance - Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that electrification of heavy-duty transport could effectively displace petroleum. This project studies the enabling technology for this goal.

Reviewer 2:

The reviewer noted that high-power WPT is arguably the application that suits WPT most, and the presenter rightly points out in the presentation that buses are ideal candidates with set routes and low fuel economy. If high-power WPT can be made to work, the petroleum reduction possibilities are massive.

Reviewer 3:

The reviewer indicated it provides easy access to costly data and analysis tools that can be applied to future research and policy decisions that affect DOE, DOT, EPA and state GHG emission reduction targets.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated for paper studies and limited test, the resources are sufficient. They would be insufficient to test on a larger scale.

Reviewer 2:

The reviewer noted that the funding for this project is adequate. The subsequent build and implementation steps will need careful consideration to achieve the same.

Reviewer 3:

The reviewer stated that, considering the scope is not defined in the presentation, it is difficult to determine whether the funding level is sufficient.

Accelerate the Development and Introduction of Advanced Technologies through Model-Based System Engineering: Aymeric Rousseau (Argonne National Laboratory) - vss153

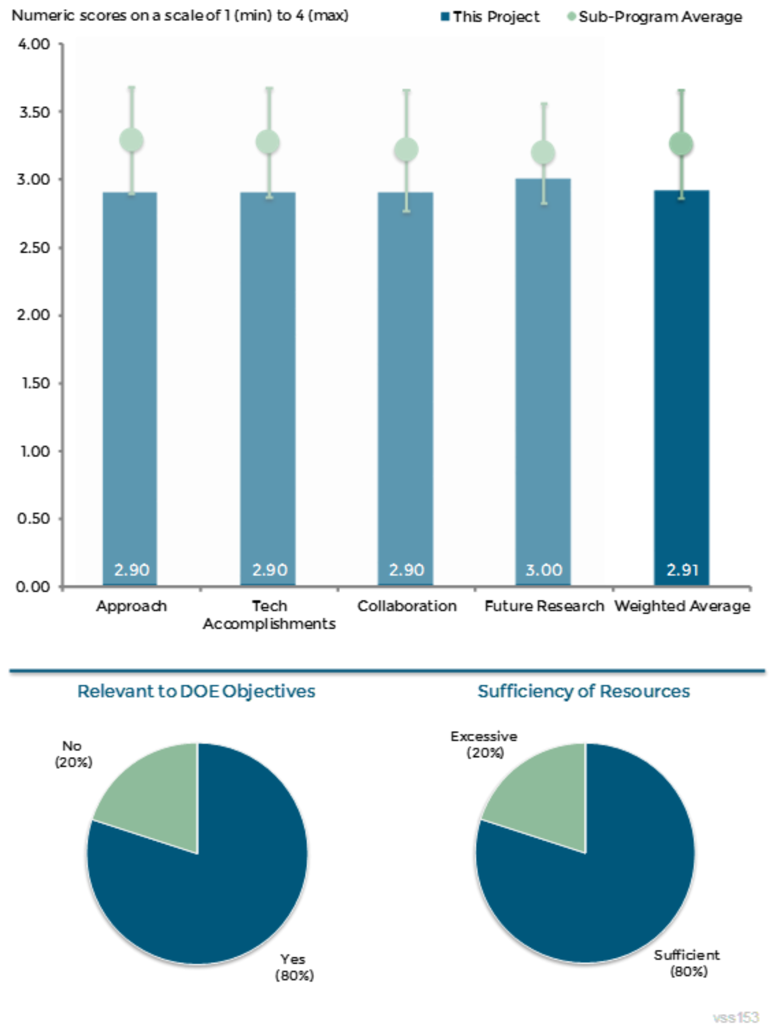


Figure 1-31 Accelerate the Development and Introduction of Advanced Technologies through Model-Based System Engineering: Aymeric Rousseau (Argonne National Laboratory) - Vehicle Systems

Presenter

Aymeric Rousseau, Argonne National Laboratory.

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that the proposed approach to exploring new areas for the next generation of automotive simulation tools is a logical progress considering the advancement in technologies and need.

Reviewer 2:

The reviewer stated that the approach to this project is excellent, specifically its emphasis on positioning Autonomie for future use through large-scale simulations and integrating additional tools expanding the Autonomie ecosystem. This will provide the flexibility for Autonomie to adapt to expected and unforeseen future needs/requirements, while continuing to enhance user flexibility and convenience. Additionally, the reviewer noted that the strong emphasis on first gathering requirements from the broad user community is on the mark. Autonomie has proven its worth as evidenced by the large user community (over 175 companies worldwide) including domestic OEMs and broad applicability with VTO.

Reviewer 3:

The reviewer liked the fact that Autonomie is versatile and robust enough to be used on heavy-duty vehicles as well as light-duty vehicles. The reviewer did not like the fact that one must also purchases licenses to Matlab and Simulink to use Autonomie; calling this a distinct disadvantage.

Reviewer 4:

The reviewer said the project seems to have a good process to evaluate maintenance and improvement needs. Shows a process diagram of connecting with customers and stakeholders and talked about prioritization of needs. The reviewer believed it might be nice to see some evidence of the collection and prioritization of needs, maybe a selection matrix, for example. The reviewer stated a personal belief that moving into large-scale simulation capability is a good direction and the approach seems sound, including simulation quality checks to flag potential issues when the user does not look at each simulation individually as in traditional single simulation.

Reviewer 5:

The reviewer indicated that the program still looks hard to use with so many technical features even though progress has been made for a large-scale simulation run. This may become more or less of an issue when it is integrated with so many other commercial codes. The reviewer believed that it may pay noticeable overhead time when it runs with other commercial codes. Also, use of Matlab/Simulink platform forces the user to have Matlab/Simulink commercial license when this program is largely funded by DOE or taxpayer dollars. Furthermore, the reviewer stated that Autonomie is a commercial product, meaning that the license fees can be significant in view of the over 175 users as stated. If that is the case, why taxpayer dollars would be used to support the large portion of this program development, which could create an unfair playing field for those commercial codes.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer stated that the project shows progress in several areas including modeling, large-scale simulation, and software enhancement.

Reviewer 2:

The reviewer believed that good progress had been made on large-scale simulation. It is difficult to measure progress against goals. The reviewer could not quite tell if the progress shown is as expected and promised to DOE.

Reviewer 3:

The reviewer stated that the task has logged an extensive and impressive list of achievements including incorporation of physical modelling, release of new thermal models, model parallelization with a new message passing interface (MPI), incorporation of large-scale study capabilities (over100,000 runs), new graphical configuration builder, model-based system engineering (MBSE) enhancements, HTML report improvements, implementation of quick launch/developer mode, decoupling of vehicle mass, updated file import scripts, user interface usability enhancements, simulation speed upgrades, and others. .

Reviewer 4:

The reviewer indicated that making the program more user-friendly and faster with MPI are the features that are nice to have.

Reviewer 5:

The reviewer believed that the goals and objectives for this project as part of the DOE VTO R&D are too ambiguous and too general as stated to determine whether the project is meeting these goals and objectives. There is nothing specific, measurable, achievable, relevant, or timely about the goals or objectives. The reviewer believed it is not clear how this project helps DOE's mission of reducing petroleum dependence and improving energy conservation.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that the project shows good collaboration from national laboratories and different sectors of the industry.

Reviewer 2:

The reviewer noted that the project works with an extensive list of well-established partners, including other model providers (national laboratories, ANL, export tool companies), and for process definition and direction, OEMs, Mathworks, Expert Tool Companies, and ANL. There are no glaring deficiencies here, although nothing was specifically mentioned with regard to universities and their specific modelling needs or potential contributions to the future direction of Autonomie.

Reviewer 3:

The reviewer stated it seems good, but felt it was unclear from the presentation what Gamma Technologies or Mathworks brought to the project.

Reviewer 4:

The reviewer believed that if Autonomie is being used on DOT- and U.S. Department of Defense-(DOD)-funded projects, then it is only reasonable to expect that DOT and DOD be made formal partners on this project.

Reviewer 5:

The reviewer was not sure how other partners are involved in this program.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer had no significant issues in this area.

Reviewer 2:

The reviewer said that, as alluded to in the approach section above, the focus on expanding the Autonomie Ecosystem with linkages to additional tools and large-scale simulation capabilities is spot-on. Autonomie will also continue to serve its traditional role in providing guidance to DOE vehicular R&D activities, while expanding the use of Autonomie throughout DOE to promote MBSE approaches. The reviewer stated that upcoming tasks/milestones for the Autonomie Maintenance and MBSE enhancement components of the project are provided in sufficient detail.

Reviewer 3:

The reviewer stated that future plans to enhance the tools are a logical approach; however, finding ways to facilitate industry and user acceptance is important for the future of this project.

Reviewer 4:

The reviewer deemed future work to be in the right direction, driven by input from customers. Large-scale simulation is the right way to go. The reviewer noted that considering the bigger picture of the whole workflow and the range of needs is good thinking and could be an area where Autonomie could set itself apart from similar tools.

Reviewer 5:

The reviewer stated that all future work plans are good., but questioned whether this can be done without using DOE funding or taxpayer dollars, because large commercial license fees may be able to support the model development.

Question 5: Relevance - Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that the project covers areas that could benefit the objectives of DOE for fuel displacement in several ways.

Reviewer 2:

The reviewer noted that many OEMs have used this program to support their product needs as well as their future technology development. Therefore, this project supports the overall DOE objectives of petroleum displacement

Reviewer 3:

The reviewer stated that there is evidence that Autonomie is used a lot by DOE programs that are working on petroleum displacement. But the reviewer noted that other tools exist to do vehicle system simulation, so continued justification for Autonomie is needed beyond having projects purchase a commercial tool. To the reviewer it looked like the value is there and DOE is getting its money's worth.

Reviewer 4:

The reviewer stated that systems modeling, as opposed to actual hardware integration/testing, is increasingly used and essential to accelerate the design and implementation of advanced vehicular technologies. Systems modelling lowers costs and improves time-to-market which leads to significant competitive advantages. The reviewer added that Autonomie is a leading tool not only for guiding DOE VTO R&D activities but also industry design, engineering, and development. While industry has tools of its own, Autonomie provides a number of highly valuable and unique capabilities with regard to vehicle controllers and framework aspects.

Reviewer 5:

The reviewer stated that no explanation was provided about the relevance of this project to petroleum displacement.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated there are sufficient resources for this project.

Reviewer 2:

The reviewer believed that $400,000 seems reasonable to keep the tool moving. The reviewer believed the team could do more with more money, but the considerations of purchasing a commercial tool should be considered as well. For whatever amount is spent on this tool development, consideration has to be given to how far that money would go in purchasing a commercial tool to use on the DOE projects.

Reviewer 3:

The reviewer indicated that the resources for this project are sufficient.

Reviewer 4:

The reviewer thought that $400,000 per year is outrageously excessive for maintenance of the software. The reviewer managed software projects before, none of which ever cost this much to maintain.

Fuel Displacement Potential of Advanced Technologies under Different Thermal Conditions: Aymeric Rousseau (Argonne National Laboratory) - vss154

Presenter

Aymeric Rousseau, Argonne National Laboratory.

Reviewer Sample Size

A total of five reviewers evaluated this project.

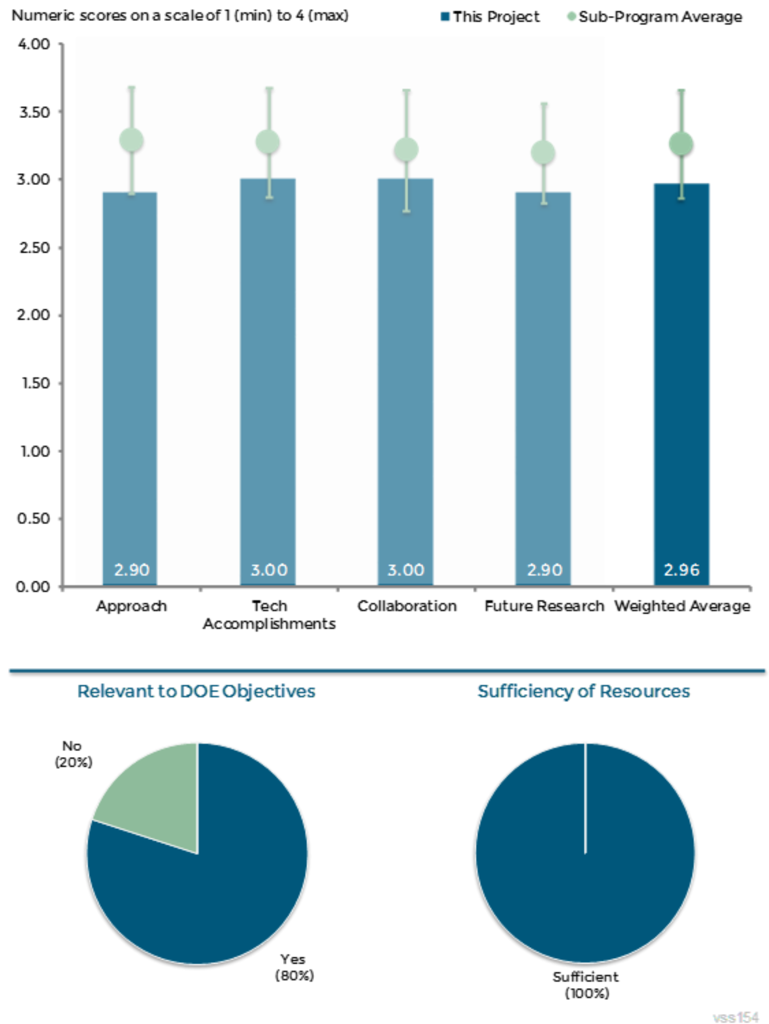


Figure 1-32 Fuel Displacement Potential of Advanced Technologies under Different Thermal Conditions: Aymeric Rousseau (Argonne National Laboratory) -Vehicle Systems

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer noted excellent overall project design. There is some inherent limitation on what can be accomplished with modeling if the intent is to move from the specific validated cases to more generic cases.

Reviewer 2:

The reviewer stated that the approach in this project follows standard procedures, because these areas have been very well covered in several studies, in particular, for conventional vehicles. Use of existing knowledge from component manufacturers, e.g., tires, can enhance the outcome of the project.

Reviewer 3:

The reviewer called the approach sound, especially using existing data and models. Using the simulation tool to evaluate temperature effects is a good approach as long as the sub-models respond to temperature with the main effects, which seems to be the case here.

Reviewer 4:

The reviewer stated that the approach is overall good except for the selection of vehicles. The selection of vehicles is solely dependent on Advanced Powertrain Research Facility (APRF) so that if a vehicle has been identified as having a thermal issue but has no APRF data, it will not be analyzed.

Reviewer 5:

The reviewer noted that the program does not detail how the approach is taken to tackle this thermal issue. Rather, it gives readers the impression that this is just an application program using Autonomie to perform the thermal analysis. The reviewer believed more description would be helpful.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer cited excellent modeling work with very good use of experimental data to validate.

Reviewer 2:

The reviewer observed that the project has shown significant progress in modeling and simulation in several areas that are important for the development of accurate thermal models for EVs.

Reviewer 3:

The reviewer stated that there is evidence that new models are in place and test data is being analyzed to validate models. When models are chosen from literature and other sources to be implemented, it would be good to show that a number of models were investigated and the most appropriate one for the needs was used. The reviewer believed it was unclear if the project is on target for progress and questioned what technologies are expected to be evaluated by the end of the project and whether progress is on plan to cover all of those.

Reviewer 4:

The reviewer noted the excellent comparisons between simulations and testing demonstrated through Slides 19 and 20. Significant simulations have been done, all of which are very informative if used and explained properly. However, this presentation fails to capitalize on this momentum, explaining why the thermal conditions impact the vehicle fuel economy. The reviewer speculated that one of the reasons is that slides on technical accomplishment are too busy with too many figures with little explanation. For example, Slide 10 could be split into at least two slides to explain the physics behind the simulations. The reviewer asked what we can learned from Slide 16, which needs more description.

Reviewer 5:

The reviewer stated that the goals and objectives of this project are not specific, measurable, achievable, relevant, or timely. It is not clear how this project fits into DOE's mission of improving energy conservation and petroleum displacement. Thus, without clear goals and objectives, it is not possible to measure accomplishments and progress.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that the project leverages data from various sources including industry, making s good use of the APRF test capability.

Reviewer 2:

The reviewer noted good collaboration with national laboratories and industry.

Reviewer 3:

The reviewer stated using test data already collected, and u sing NREL model.

Reviewer 4:

The reviewer believed it is not clear how the partners are involved in the program.

Reviewer 5:

The reviewer questioned whether the results showed that ambient temperature has a significant impact on EVs. If not, the reviewer inquired about why EV manufacturers are not made partners.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that the future plan is excellent because this program will be tested using real-world conditions.

Reviewer 2:

The reviewer stated that no more work is planned; this is the last year.

Reviewer 3:

The reviewer noted that the future work is very ambitious and questioned if the scope is becoming too wide.

Reviewer 4:

The reviewer stated that the project explained that the future plans include evaluation of energy consumption with the vehicle thermal management system (VTMS) using real-world conditions, use of new modeling technologies, and optimizing energy management strategy. However, more details on these approaches should be added. The reviewer noted that the project can use this knowledge to expand to other vehicle types.

Reviewer 5:

The reviewer stated it is generally clear where it is going but light on specifics of what technology evaluations are really critical. The reviewer noted that the tire thermal model was implemented, but asked whether that was because it was available or because it really matters. The reviewer asked what the next most critical thermally sensitive model is.

Question 5: Relevance - Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer noted that improved model fidelity helps to ensure DOE objectives are realistic with regard to technology options.

Reviewer 2:

The reviewer stated because this study reviews a template that has significant impact on EV energy consumption.

Reviewer 3:

The reviewer stated that moving into the area of temperature effects is a good place to go. There really is no average day so starting to understand the sensitivity of new technologies to ambient temperatures is a good direction to help fuel efficiency improvement projects.

Reviewer 4:

The reviewer noted that the model developed under this program helps developers understand why thermal conditions are important, thus developing solutions to those potential barriers. The reviewer believed this would aid development of more efficient components. Therefore, this project supports the overall DOE objectives of petroleum displacement.

Reviewer 5:

The reviewer found it unclear how this project supports or relates to petroleum displacement.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer stated that the resources seem to be sufficient for this project. The team is getting a lot done.

Reviewer 2:
The reviewer indicated that this is the last year of funding for this project.

Reviewer 3:
The reviewer stated that sufficient funds are available for this project.

Analyzing Real-World Light-Duty Vehicle Efficiency Benefits: Jeff Gonder (National Renewable Energy Laboratory) - vss155

Presenter

Jeff Gonder, National Renewable Energy Laboratory.

Reviewer Sample Size

A total of five reviewers evaluated this project.

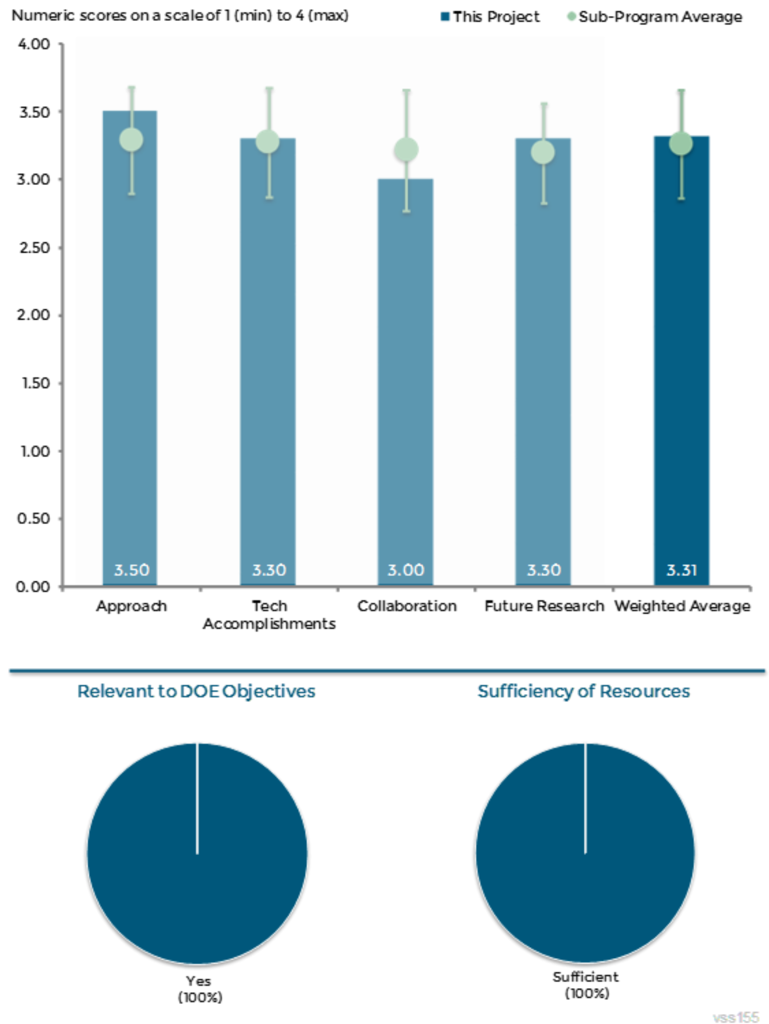


Figure 1-33 Analyzing Real-World Light-Duty Vehicle Efficiency Benefits: Jeff Gonder (National Renewable Energy Laboratory) - Vehicle Systems

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer noted that the comprehensive approach taken to consider a variety of drive cycles will help assess the potential benefits.

Reviewer 2:

The reviewer believed that the approach is comprehensive and fully leverages all the tools and data at the disposal of the team. Well-developed methods are successfully applied from previous projects.

Reviewer 3:

The reviewer stated that the evaluation of the benefits of new technologies under real-world application provides more accurate data than standard cycles.

Reviewer 4:

The reviewer believed that modeling should include mass trade-off to fuel efficiency gains.

Reviewer 5:

The reviewer stated that the approach taken is good if it can be proved, but the big question remains how such a simplified tool model can evaluate complicated technologies and their benefits. Calibration against one vehicle or technology can be good with tuning model constants, but the reviewer questioned if these model constants would be applied to other similar cases.

The model needs to demonstrate the relative comparisons between A and B in many scenarios as opposed to testing data.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:
The reviewer stated that the progress and results to date are excellent. Useful findings that leverage the available resources of the DOE laboratories to the fullest extent possible.

Reviewer 2:
The reviewer stated very useful information for the auto industry and research community

Reviewer 3:
The reviewer stated that extrapolation of the Real World Benefit Estimate to the current and anticipated national LDV fleet may provide a more compelling illustration of the value of the research to both vehicle manufacturers and policy makers.

Reviewer 4:
The reviewer believed that involving more sets of real-world data from vehicles, with identified features for fuel economy improvements, will aid in the A/B technology comparisons.

Reviewer 5:
The reviewer stated that it is important that the model is calibrated against testing in absolute values. However, it is more important to compare the relative comparisons between A and B technologies against the experimental data in A and B, because this kind of tool is not designed for high-accuracy simulations. The reviewer indicated that Slide 15 only shows simulations between A and B. The reviewer asked about testing data in A and B.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer noted excellent collaboration between ANL, OEMs and NREL. The reviewer asked if EPA should also be involved.

Reviewer 2:
The reviewer believed that more opportunities could be realized by involving OEMs directly in this effort, as well as the EPA, by providing vehicles for testing and technical support that can possibly leverage a change in EPA rulings.

Reviewer 3:
The reviewer believed that more OEMs should be involved.

Reviewer 4:
The reviewer indicated that coordination with DOT and State Highway Agencies (SHAs) could provide data that would provide a more robust model.

Reviewer 5:
The reviewer believed that it is not clear how partners are involved in the program.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer stated that the proposed work is on-target.

Reviewer 2:
The reviewer indicated that incorporating roadway condition information from SHAs should be considered to strengthen conclusions concerning the impact of pavement smoothness.

Reviewer 3:
The reviewer questioned if the team considered testing vehicles equipped with map-based features that learn the same route, and determine the potential benefits toward additional credits.

Reviewer 4:
The reviewer noted that the future work should at least includes two parts - improve the model fidelity (not mentioned), and A/B comparisons (not clear whether it was only simulations with A and B or benchmark against testing in A and B or combination of both).

Question 5: Relevance - Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer believed this is a good, methodical way to try to capture the benefits of technologies that can provide off-cycle fuel economy improvements. This can encourage OEMs to have greater confidence in implementing these technologies if sufficient off-cycle credits are allowed.

Reviewer 2:
The reviewer stated that this research will help to better understand the real-world operation characteristics of light-duty vehicles, which provide very useful input to OEMs in vehicle design and powertrain calibration.

Reviewer 3:
The reviewer noted that if this work can be calibrated in a reliable way, this model can play an important role in achieving the objective the program states. Continuing work on this goal will support the overall DOE objectives of petroleum displacement.

Reviewer 4:
The reviewer indicated that this not only supports DOE objectives, but also the DOT Clean Transportation Sector Initiative goals of 80% GHG emissions reductions by 2050, as well as EPA objectives. Consider potential for incorporating PV on surfaces to provide power-assist to vehicle accessories.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer considered that the resources are sufficient for the current work stream.

Smart Grid Requirements Study: Tony Markel (National Renewable Energy Laboratory) - vss156

Presenter

Tony Markel, National Renewable Energy Laboratory.

Reviewer Sample Size

A total of three reviewers evaluated this project.

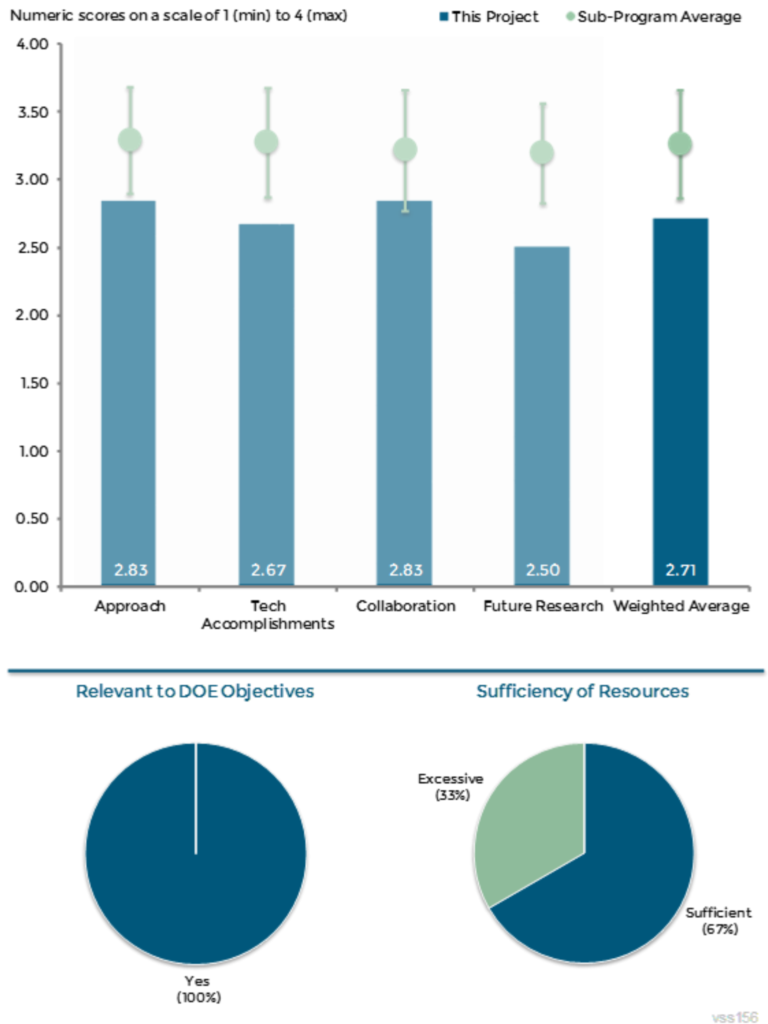


Figure 1-34 Smart Grid Requirements Study: Tony Markel (National Renewable Energy Laboratory) - Vehicle Systems

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that the technical approach of the project shows good planning and steps. Also, involving several national laboratories adds strength to the project but should be focused. However, assessing battery life and vehicle performance should have high priority in the project.

Reviewer 2:

The reviewer noted that the project was titled "requirements study" but it was not clear how the work presented flowed from that. The outline of deliverables is impressive and seems solid, but the presentation did not talk much about the approach to these various tasks.

Reviewer 3:

The reviewer indicated that the project approach was inappropriate for defining requirements for PEV integration with a smart electric grid. The study should have defined a hierarchy of goals and objectives, key performance parameters, value metrics, and requirements scenarios. To the reviewer it appeared that the approach taken was inappropriately focused on implementation approaches for performing pet investigations that are focused on a very narrow set of PEV-grid interaction concepts (e.g., vehicle to grid [V2G]).

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer stated that the project shows good progress in technical areas similar to system integration, characterization, and test procedures. However, work on battery life and cost needs to show more results.

Reviewer 2:
The reviewer noted that the presentation did not present the results of the various task outlined. It was difficult to judge the value of the accomplishments because most of them were not presented. In general, the concepts discussed seem very valuable. The reviewer believed it would have been helpful to see more of the details of the accomplishments.

Reviewer 3:
The reviewer indicated that the lack of requirements for PEV-smart grid integration from the PEV system perspective is the critical barrier that this study was intended to address. The work performed was too narrowly focused to overcome the critical barrier.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer noted good collaboration with national labs. However, more involvement of industry could speed and enhance project results.

Reviewer 2:
The reviewer noted that there appears to have been copious collaboration between the laboratory participants but the objectives/statement of work for those collaborations were off target. In general, a key component of collaboration that appears to be missing from the project is inputs and feedback from a broad range of stakeholders.

Reviewer 3:
The reviewer indicated that conceptually the collaboration among laboratories seemed strong. However, it was not clear from the presentation how the various tasks highlighted for each laboratory support the requirements of the study of requirements.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer stated that the goals spelled out in the future plans are reasonable. However, more details about the approach should have been explained here.

Reviewer 2:
The reviewer stated that there needs to be a much clearer strategy for how the joint laboratory efforts support overall requirements for grid integration for DOE. If this exists, it was not presented. The reviewer recommended a much clearer active involvement from industry to guide the requirements.

Question 5: Relevance - Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer stated that the goal of defining requirements for PEV-grid integration is critical to the opportunities for transportation electrification to contribute to DOE objectives of petroleum displacement. Proper design of PEV-to-grid interactions will increase the ability of the U.S. transportation sector to employ a broad range of energy sources to power its vehicles.

Reviewer 2:
The reviewer noted that it could support DOE objectives of petroleum displacement, if the project can solve battery life and cost issues.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer noted that the rating of sufficient assumes that the project is a three-year project with level funding each year.

Reviewer 2:

The reviewer indicated that the project has sufficient funding.

Reviewer 3:

The reviewer stated that the amount of funding focused on requirements seems very excessive, but it appears other things are being done with the funding than just requirements.

Unitary Thermal Energy Management for Propulsion Range Augmentation (UTEMPRA): Sourav Chowdhury (Delphi Automotive Systems LLC) - vss157

Presenter

Sourav Chowdhury, Delphi Automotive Systems LLC.

Reviewer Sample Size

A total of three reviewers evaluated this project.

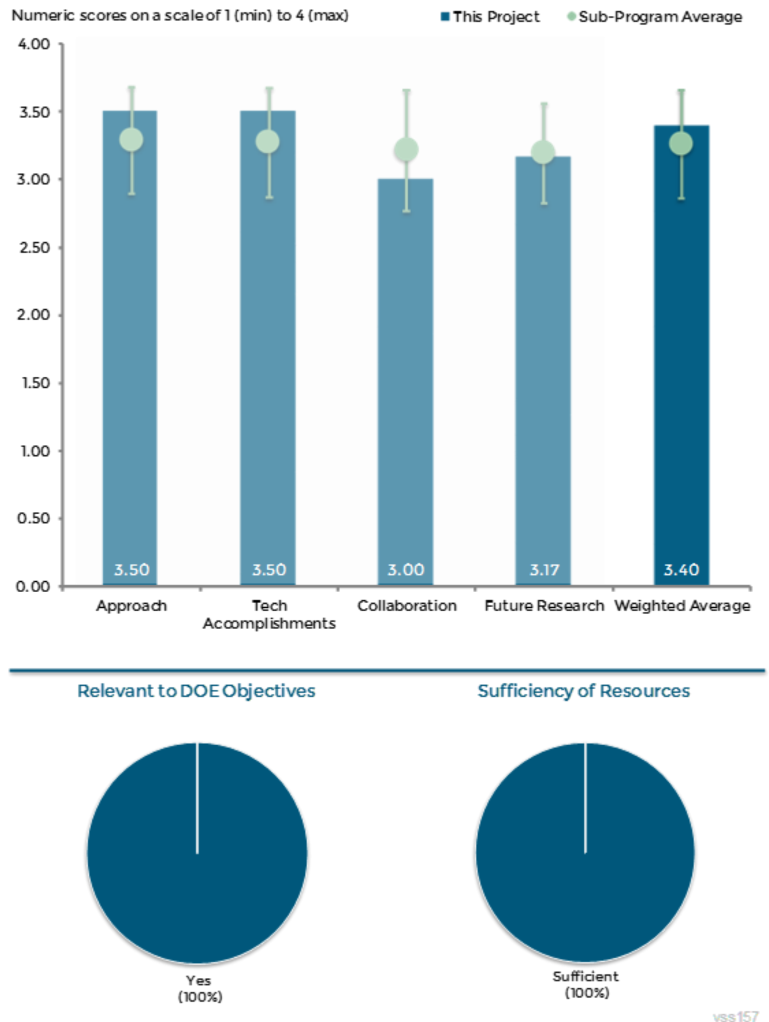


Figure 1-35 Unitary Thermal Energy Management for Propulsion Range Augmentation (UTEMPRA): Sourav Chowdhury (Delphi Automotive Systems LLC) - Vehicle Systems

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer indicated that this is an excellent example of innovation and concept development which may have, if successful, significant future benefit.

Reviewer 2:

The reviewer stated that the basic level design and packaging work is very good, though the subsystems are not novel. Identification of the commercial-level barriers did not seem clear, tough system level requirements are well defined.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer stated that this type of program is essentially an enabling technology development and if a multi-mode flow controller (MMFC) can be demonstrated with production issues addressed there will be real benefit in thermal design.

Reviewer 2:

The reviewer stated that this project is well within the first year of work. Packaging, design, layout work, and baseline tests complete.

Reviewer 3:
The reviewer noted that though percentage of the work completed seems low, the amount of completed project requirements, packaging and other system requirements is very good, and shows complete understanding of the system level required.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer noted an appropriate blend of suppliers, OEMs, and national laboratories.

Reviewer 2:
The reviewer believed that the collaboration is okay, but could be improved upon with additional OEM input.

Reviewer 3:
The reviewer stated that the required partners are included, but commercial viability may require additional information about regional benefits and sensitivity to actual consumer usage profiles.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer stated that test evaluation with hardware integration of the new HVAC system will be welcome in the next review. Standardized drive cycles in the evaluation stage are important for comparison to other systems; it will be interesting to see what EPA suggests for this project.

Question 5: Relevance - Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer indicated that increasing the range of EVs in cold environments would increase their adoption and reduce petroleum consumption.

Reviewer 2:
The reviewer stated this project goal is identical to the other EV heating projects; cold-weather EV heating range reduction must be addressed in order to advance the technology in the marketplace. This work will demonstrate one approach to finding range improvement under such conditions.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer indicated that though the progress is good and the plan is sound, the lack of novel technologies indicates that the systems integration and packaging study are the main deliverables. If there are specific goals that will be obtained in development that will be novel, like the layered heat exchanger and unique brazing process.

Zero-Emission Cargo Transport Projects (ZECT): Nancy Cole (SCAQMD) - vss158

Presenter

Joseph Impullitti, SCAQMD.

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

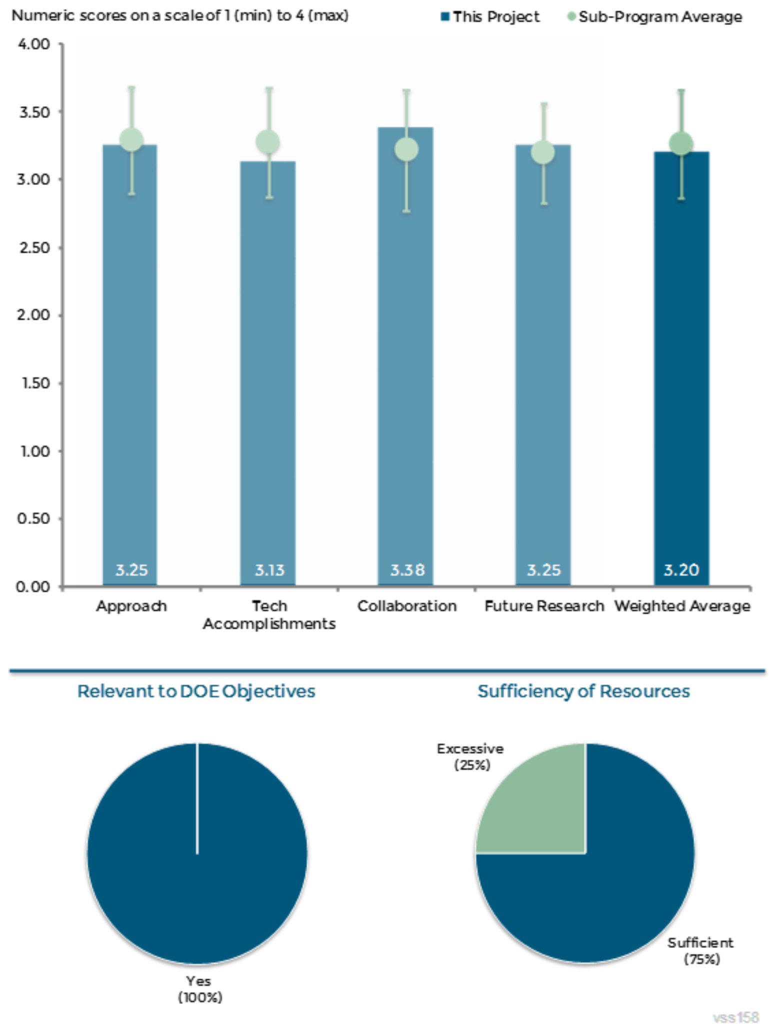


Figure 1-36 Zero-Emission Cargo Transport Projects (ZECT): Nancy Cole (SCAQMD) - Vehicle Systems

Reviewer 1:

The reviewer stated that this is an excellent project in what is widely viewed as an optimum application of zero emission technology. That is in effect short-range heavy transportation of goods in a seaport environment (drayage truck).

Reviewer 2:

The reviewer stated that the project and project support appear to be well coordinated (year 1 project).

Reviewer 3:

The reviewer indicated that the stated approach has several strong elements including building off previous and ongoing projects' vehicle technologies and infrastructure; requiring contractors to have experience with fuel cell or battery electric truck and bus development (which will hopefully minimize the likelihood that particular contractors will be unable to deliver); selecting a variety of contractors to pursue multiple, different truck configurations (minimizing risk should one of the contractors run into trouble); and requiring contractors to partner with a major OEM and design for manufacturability (maximizing the potential for long-term commercial viability of the developed systems). The reviewer noted that the presentation did not explicitly mention plans for a rigorous cost/benefit analysis of the price point that the vehicles will need to reach in order to have their fuel displacement achieve economic payback relative to conventional vehicle alternatives (without necessarily relying on subsidies), but the presenter indicated that an analysis of this sort is planned and will also quantify infrastructure costs. The reviewer noted that it will be important to include such an analysis—ideally with the participating manufacturers assessing and reporting what will be required to achieve these costs, and with state agencies quantifying the value of individual Zero Emission Cargo Transport (ZECT) vehicle contributions to air quality improvements in order to evaluate the reasonableness of any long-term incentive needs.

Reviewer 4:

The reviewer indicated that there seems to be a large number of different architectures to be evaluated in this project. No mention of vehicle simulation and modeling was made in the vehicle selection text, though the presenter commented on the capabilities of the partners. The reviewer noted that comparison of the results/performance related to each architecture will be difficult given the great variation in infrastructure investment that may be required in connection with some of the architectures.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer stated that, if successful in overcoming fueling infrastructure and costs, this project can demonstrate a game-changer in similar applications.

Reviewer 2:

The reviewer indicated that the project appears to be well managed at this point.

Reviewer 3:

The reviewer stated that the project was awarded in October and is not scheduled to kick off with its contractors until later this month, so accomplishments to date were limited to the vehicle concepts that have been proposed/selected. The presentation described a number of these concepts and included enough detail to convey that a reasonable level of rigor went into their development, and that the selected contractors should be expected to succeed on their development plans. The reviewer indicated that the approach section included good qualitative criteria for contractor selection, but as this selection process represents the entirety of project accomplishments thus far, it would have been good to see more details/specifics about how the winning contractors demonstrated convincing long-term commercialization plans, and to get a sense of the number of proposals received relative to the number of awards granted.

Reviewer 4:

The reviewer stated that many of the partners have made good progress on their particular deliverables, but the true test of the deliverables will be when the vehicles are in field test or validation dyno testing.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted a large group of integrators, each with appropriate deliverables and responsibility for system evaluations.

Reviewer 2:

The reviewer noted that the presentation did not include a comprehensive collaboration and coordination summary slide. By its nature, the project includes multiple collaborators in the form of the contractors awarded to design, build and deliver the ZECT vehicles. The reviewer indicated that as the kickoff has yet to occur with the contractors it is difficult to assess how effective the coordination with these contractors will be, but there has at least been enough coordination so far for South Coast Air Quality Management District (SCAQMD) to select the awardees and include details on the vehicle designs in the presentation. The overview slide indicated $7 million contributed by funding partners as a separate item from the $3 million contractor cost-share but the reviewer did not catch who those funding partners include. The reviewer expressed the opinion that it would be good to have these partners called out as collaborators in the presentation.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer indicated that the future work is to include design, integration and delivery of the vehicles by the contractors, then a 24-month on-road demonstration period for each. It is good that these future plans include a rigorous comparison to 2012 or newer baseline vehicles in order to accurately benchmark the benefits and challenges of the ZECT vehicles with respect to costs, performance, reliability, effectiveness and needed refinements. The reviewer stated that the future work should also maintain a sharp focus on long-term commercial viability, and ask the contractors to detail their strategy and likely timing to transfer technologies supported through this project award into successful commercial products.

Reviewer 2:

The reviewer stated that in today's environment, economic impact of technology on increased costs to the shippers or OEMs must be taken into account. In this case, the aggregate economic impact on either the increased cost of tonnage of shipping (ultimately trickling down to the consumer), or the taxpayer, should be included.

Reviewer 3:

The reviewer stated that as the team is early in the project there is much opportunity for future work, perhaps too much, as there are so many system architectures. Future work to align specific architectures with specific duty cycles would be a great additional effort.

Question 5: Relevance - Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer noted that the project stands to deliver a small amount of petroleum displacement from the individual demonstration vehicles, and a much larger level of displacement if the project makes possible long-term commercialization of the supported technologies in larger numbers.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that the significant cost of developing and delivering zero emission cargo transport vehicles makes the cost of this project understandably large. However, in comparison to other demonstration programs (such as those supported under ARRA that required roughly 50% contractor cost share), the 15% contractor cost share ($3 million/$20 million) seems a bit low. The reviewer felt that requiring contractors to put up a larger percentage of the required funds would increase their incentive to get the technologies integrated into future product offerings and thus achieve a return on their internal investments.

Medium-Duty ARRA Data Reporting and Analysis: Ken Kelly (National Renewable Energy Laboratory) - vss159

Presenter

Bob Prohaska, National Renewable Energy Laboratory.

Reviewer Sample Size

A total of four reviewers evaluated this project.

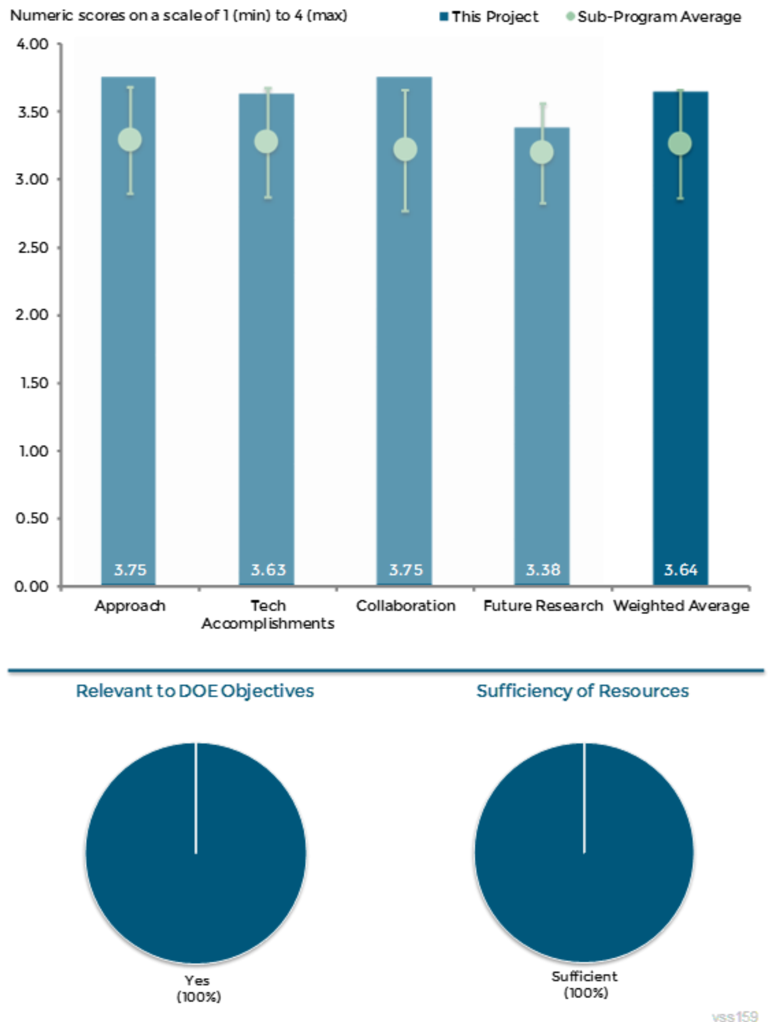


Figure 1-37 Medium-Duty ARRA Data Reporting and Analysis: Ken Kelly (National Renewable Energy Laboratory) - Vehicle Systems

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer noted great work on collecting data on various technology deployment projects for advanced technologies in commercial vehicles. The projects are well structured and the data is methodically and rigorously handled, and can be retrieved and analyzed in subsequent projects.

The reviewer stated that there are apparently several, similar NREL project relating to collecting and analyzing data for fleets (on various levels). It would be good to have an overview of how these projects relate to each other and to see whether any overlap or gaps exist in the overall data collection and analysis efforts.

Reviewer 2:

The reviewer stated that this effort is right on target with shaping the industry perceptions of these new technologies. The barrier related to the long-term viability of the OEMs may need more attention and support. The reviewer noted that collecting and reporting on operational availability, amount of maintenance and parts consumed, and logistics downtime could bolster the first barrier.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer stated that three completed deployment projects, along with reports, in addition to two ongoing projects are a respectable output for the reporting period.

Reviewer 2:

The reviewer noted being unaware of an automotive data collection effort superior to this.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer indicated that it is apparent that close collaboration with fleet and technology partners is required to achieve these results. Good work.

Reviewer 2:

The reviewer stated that this project has to achieve a wide range of collaboration in order to execute.

Reviewer 3:

The reviewer stated that some coordination with SHAs or other site owners for charging stations should be sought to obtain feedback on the impact on their operations or utility costs. The SHAs may also provide road condition data by road network or region that would be relevant to the outcome of this study.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer noted that the proposed future work is on target. The potential for identifying optimal truck configurations of payload, power, and energy capacity for different vocations could really change the industry for the consumers and the OEMs. The reviewer stated there was great potential to drive down costs through volume production.

Reviewer 2:

The reviewer stated that it would be good to present what specific technologies will be priorities in the coming years to be able to assess whether the most relevant technologies are being evaluated and the right emphasis is being placed (e.g., HEV, BEV, PHEV, hydraulic hybrid).

Otherwise the future work is a little opaque.

Reviewer 3:

The reviewer noted that there appears to be an inconsistency between the timeline presented in the overview and the proposed future research on Slide 22. Although there is no scope identified on the slide, future research considerations of interest to fleets would be maintenance trade-offs and the availability of charging stations. The reviewer stated that DOE should coordinate with DOT/SHAs for future investments in charging facilities as the next Surface Transportation Legislation is finalized.

Question 5: Relevance - Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that this project will identify areas in which the technology performs best by vocation. Good project.

Reviewer 2:

The reviewer indicated that this not only supports DOE objectives, but also the DOT Clean Transportation Sector Initiative goals of 80% GHG emissions reductions by 2050, as well as EPA objectives.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

No comments were received in response to this question.

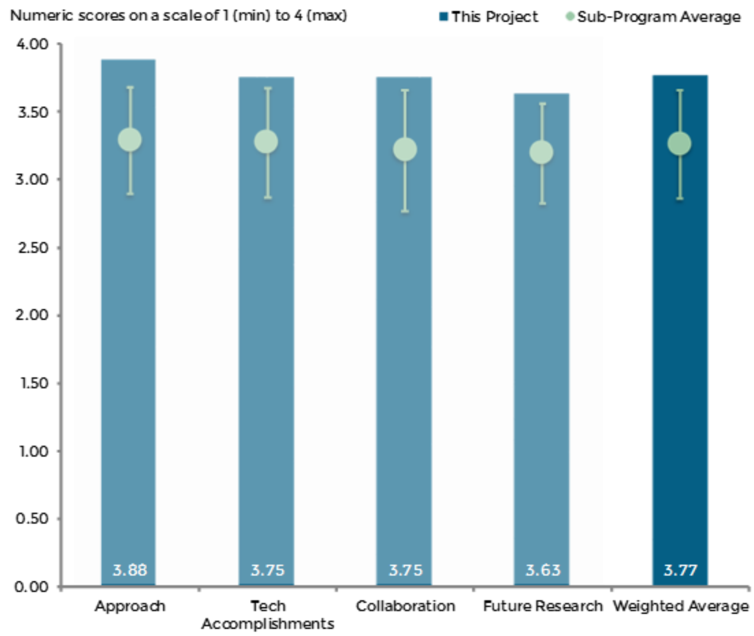
Fleet DNA Phase 1 Refinement and Phase 2 Implementation: Ken Kelly (National Renewable Energy Laboratory) - vss160

Presenter

Adam Duran, National Renewable Energy Laboratory.

Reviewer Sample Size

A total of four reviewers evaluated this project.



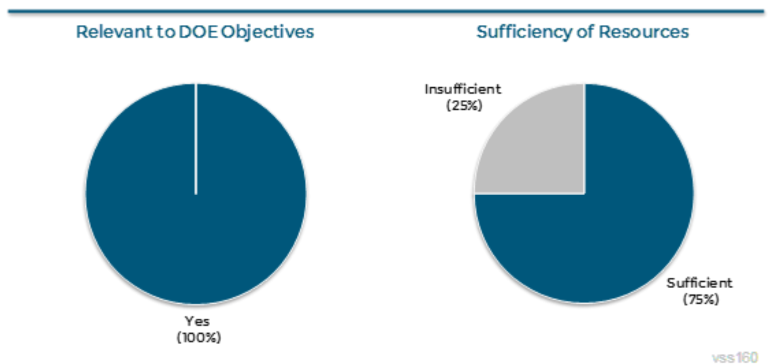


Figure 1-38 Fleet DNA Phase 1 Refinement and Phase 2 Implementation: Ken Kelly (National Renewable Energy Laboratory) - Vehicle Systems

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that this is the Manhattan Project for advanced powertrains/systems for commercial vehicles. The only potential area of improvement is to work with the users of this capability with the intent to refine the products.

Reviewer 2:

The reviewer stated that this is an excellent attempt to replace a dead system, VIUS, with a much less cumbersome process to get field data for developers of new technologies. The reviewer emphasized that this can be done without bothering people with a survey document. This level of data collection seems appropriate.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer stated that this effort is very difficult to improve at this point. Now that this information is available it will take some time to see how the outside world will use it. The reviewer would expect that the desire for new types of analyses will emerge over time.

Reviewer 2:

The reviewer stated that the project seems on scope and completing the data collection on a timely basis. It also seems from the examples shown that this tool is desired and being used already. The reviewer remarked that the team was doing a good job.

Reviewer 3:
The reviewer noted an excellent portal for ease of data access and visualization tools.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer stated that this project sets the bar for collaboration and coordination.

Reviewer 2:
The reviewer emphasized an excellent list of manufacturers, end-users and governments/non-governmental organizations (NGOs) on the lists. It definitely seemed to the reviewer that the team is engaged and interested in using this data for their efforts to match up with other customer quality deployment data collection.

Reviewer 3:
The reviewer stated that some value may be found in collaborating with SHAs and metropolitan planning agencies that may have symbiotic interests.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer stated that the plan to start collecting and storing laboratory data is excellent. Additionally, the future plan to fold in the simulation capability will really open the door for optimizing vocation-specific platforms.

Reviewer 2:
The reviewer indicated that getting additional data per the plan is critical and continuing to test the tools with interested parties will ensure their ongoing use by an increasing number of stakeholders. The reviewer questioned how this tool will be further marketed for understanding, noting that this is not readily discussed. The reviewer hears more about how unfortunate it is that VIUS is gone and appreciates trying to promote this more, but does not see the results in the industry yet. This is important work now and down the road as the database matures.

Reviewer 3:
The reviewer noted that additional value may be found by incorporating data sets such as traffic congestion, road condition and weigh-in-motion data to see what effect it has on the fleet performance by vehicle class, road network and/or region.

Question 5: Relevance - Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer deemed this one of the most significant projects in these sessions. Field data is critical to developers, integrators and fleets. The project should have a huge benefit in technologies being available and on accelerating their adoption in the real world.

Reviewer 2:
The reviewer called this very important information for future development of propulsion technologies.

Reviewer 3:
The reviewer stated that the project provides easy access to costly data and analysis tools that can be applied to future research and policy decisions that affect DOE, DOT, EPA and State GHG emission reduction targets.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer indicated that given the massive amount of data collection, coordination, processing, quality assurance (QA), storage, security, analytics and dissemination, the funding available appears to be modest.

Reviewer 2:

The reviewer said resources seem appropriate.

Multi-Speed Gearbox for Commercial Delivery Medium-Duty Plug-In Electric Drive Vehicles: Bulent Chavdar (Eaton Corporation) - vss161

Presenter

Bulent Chavdar, Eaton Corporation.

Reviewer Sample Size

A total of four reviewers evaluated this project.

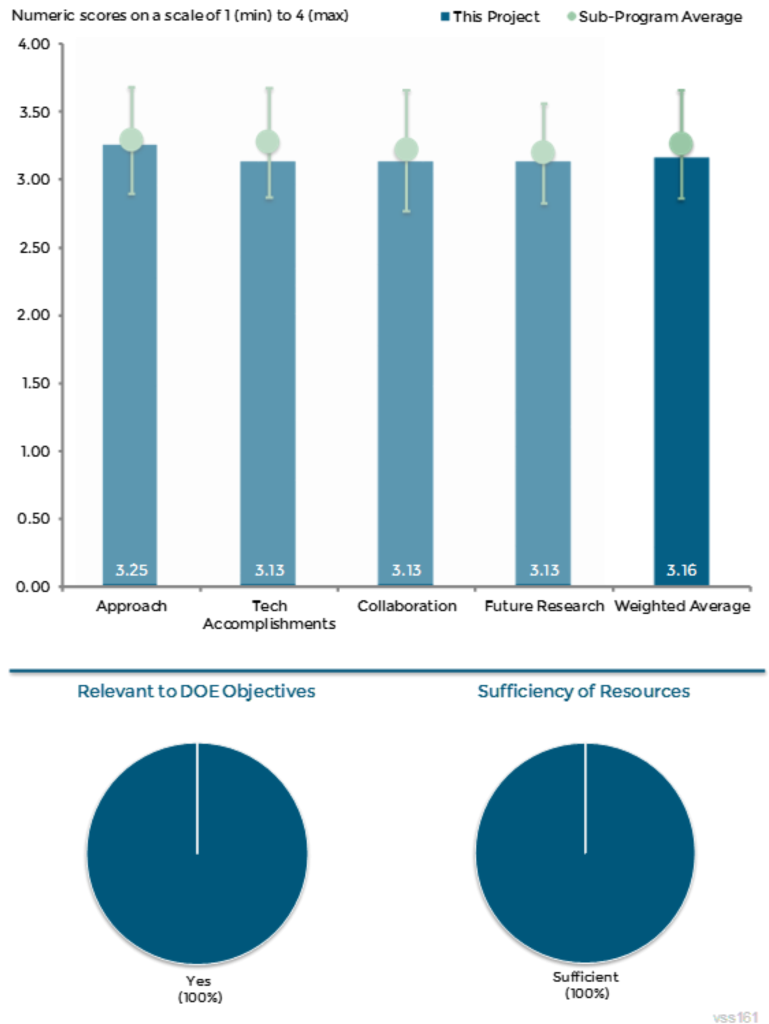


Figure 1-39 Multi-Speed Gearbox for Commercial Delivery Medium-Duty Plug-In Electric Drive Vehicles: Bulent Chavdar (Eaton Corporation) - Vehicle Systems

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer noted that the approach and strategy in Slide 5 is comprehensive. Because application of this technology can be extremely expensive, which may prohibit its acceptance by the market, this issue must be addressed, specifically with potential payback time.

Reviewer 2:

The reviewer noted that it was building on the strengths of ORNL and NREL. Good comparisons to baselines. The reviewer believed it had strong business case development, which is not always seen on these types of DOE programs.

Reviewer 3:

The reviewer stated that the project objectives and how they relate to DOE goals are not stated in the presentation, therefore it is unclear whether the approach is adequate and what the scope of the project is.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer stated that deliverable goals are being met. This is a good topic, but the reviewer questioned the EV volumes in this space and the contribution of such a transmission. The reviewer appreciated Eaton and DOE working on this. The reviewer asked if benefits in acceleration and top speed are really needed. The reviewer understood the increase in gradeability and fuel economy, but questioned the results from voice of customer work shared in Slide 11, and suggested this might be validated a bit more.

Reviewer 2:

The reviewer indicated that performance metrics are not provided, so found it difficult to determine whether the progress is sufficient.

Reviewer 3:

The reviewer noted that the approach taken to analyzing EV transmission volume is misleading because one of the keys to see market penetration is the payback period and cost. Only presenting projection on volume is not enough. The reviewer asked what the y axis for the figures in Slide 10 is and what DFSS (Design for Six Sigma) means. The reviewer said do not assume that all readers can understand all acronyms.

The reviewer said if capital cost and price of transmission would be overwhelmingly important (Slide 11), the cost should have been addressed. However, this has not been done yet.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that having two national laboratories plus Smith is good.

Reviewer 2:

The reviewer stated that collaboration, communication with other fleet owners, such as SHAs, who often have GHG emission reduction targets, may be valuable to provide information for future equipment purchase decisions.

Reviewer 3:

The reviewer did not see end–users as partners; the reviewer thought that might really help here with inputs to the business case and to help with tradeoffs in the design.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer indicated that a good plan seems to be in place.

Reviewer 2:

The reviewer noted that some analysis on return on investment should be provided and also related to existing technologies.

Reviewer 3:

The reviewer indicated that in BP1, capital cost of the system, price of the transmission, and total operation with payback time should be included. Without this plan, this program provides less value to public.

Question 5: Relevance - Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that this not only supports DOE objectives, but also the DOT Clean Transportation Sector Initiative goals of 80% GHG emissions reductions by 2050, as well as EPA objectives.

Reviewer 2:

The reviewer stated that the system will use less energy.

Reviewer 3:

The reviewer agreed that the project supports DOE objectives somewhat, but with the low uptake of EVs the reviewer was unsure this is essential to investigate.

Reviewer 4:

The reviewer was unsure because of the extremely high cost and its payback time in the medium-duty (MD) world. Customers may not accept this approach unless payback and cost issues can be addressed in this program.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

There were no reviewer comments on resources.

Integrated Boosting and Hybridization for Extreme Fuel Economy and Downsizing: Vasilios Tsourapas (Eaton Corporation) - vss162

Presenter

Vasilios Tsourapas, Eaton Corporation.

Reviewer Sample Size

A total of four reviewers evaluated this project.

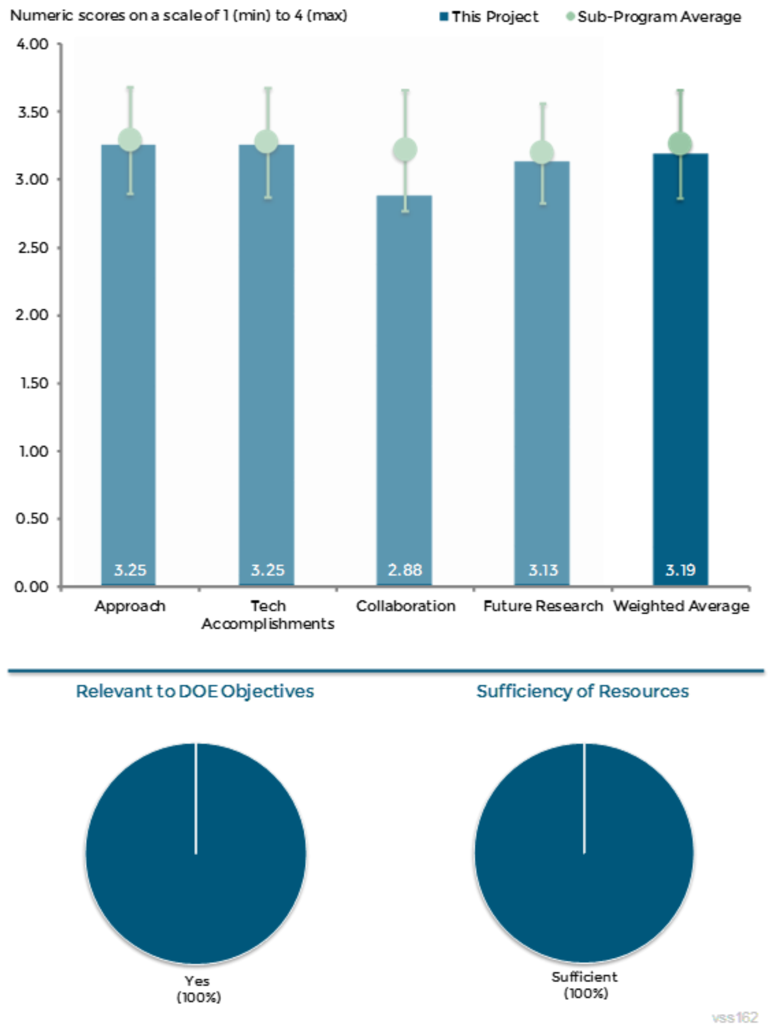


Figure 1-40 Integrated Boosting and Hybridization for Extreme Fuel Economy and Downsizing: Vasilios Tsourapas (Eaton Corporation) - Vehicle Systems

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer considered this an interesting technology application and a good plan for initial development and technology evaluation

Reviewer 2:

The reviewer stated that the project approach is generally effective. The plan should address the main issues with this system in regard to durability and electric power compatibility in the early stage of the project.

Reviewer 3:

The reviewer stated that it would be nice to have a comparison of how these technologies compare in cost to other alternatives for improving fuel economy. The Roots expander and hybrid supercharger are interesting technologies. The reviewer indicated that a comparison with other technologies might help justify the selection of these technologies for application on an engine (and could help answer any potential questions about whether Eaton has selected off-the-shelf technologies for this project).

Reviewer 4:

The reviewer stated that the first project year is difficult to judge properly. Some packaging and base design work has been completed. Next year will prove more telling.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer stated that the project shows good progress in the areas of simulation and material and component development.

Reviewer 2:
The reviewer noted that though the team is early on in the project, the schedule is clearly defined, and being ahead of schedule on the modeling allows additional evaluation time for waste heat and engine integration.

Reviewer 3:
The reviewer stated that the packaging and base design has some work completed. Difficult to properly gauge the project as it has only been working for a few months.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer stated that this is the proper mix required for such a demonstration.

Reviewer 2:
The reviewer stated that collaboration seems reasonable. Addition of a partner that actually manufactures engines might improve the project (not clear if that is possible).

Reviewer 3:
The reviewer noted a good group of collaborative partners that encompass the systems immediately impacted by these two systems, but there remains a question in overall vehicle-related requirements.

Reviewer 4:
The reviewer stated that the project could improve collaboration by using partners from national laboratories and industry.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer indicated that modeling, design, development and in-vehicle demonstration is the proper plan for such a technology.

Reviewer 2:
The reviewer stated that it will be very interesting to following this leading-edge application of these technologies.

Reviewer 3:
The reviewer stated that the project uses a standard project development plan that covers all requirements for having a final product.

Reviewer 4:
The reviewer indicated that one area for potential future research is further exploration of the interactions of these systems with engine calibration. The reviewer questioned how the engine calibration might be optimized to help improve overall system performance. It was not clear how much work in the future will be focused on engine calibration development, but it seems this would be an important area to get the best performance from the powertrain system as a whole. The reviewer stated that understanding the impact of the Roots system on backpressure, and how the backpressure impacts peak cylinder pressure constraints, engine durability, and efficiency will be important to understanding the potential impact of the system.

Question 5: Relevance - Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer indicated that hybrid supercharging should enable downsizing, start/stop, and some energy capture, all of which save fuel. The Roots expander saves fuel by capturing waste exhaust energy.

Reviewer 2:
The reviewer stated that the predicted 20% improvement over turbocharged baseline is an aggressive target. If the target is met, it will demonstrate an effective and cost-effective technology.

Reviewer 3:
The reviewer noted that the obvious impact of 20% improvement of fuel economy would align with DOE goals, as well as taking advanced technology into deployment for transportation efficiency

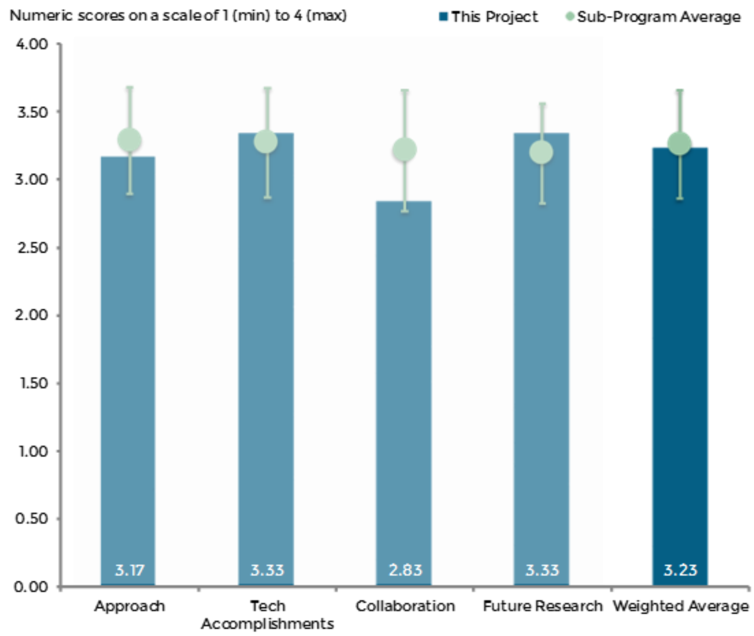
Reviewer 4:
The reviewer stated that if successful it could make significant improvement for engine downsizing and thus fuel consumption savings.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer noted an interesting combination of systems into one project; the controls required to balance these two systems to achieve optimization may require additional vehicle-related tuning

Reviewer 2:
The reviewer stated that the project has sufficient resources.

Advanced Bus and Truck Radial Materials for Fuel Efficiency: Justin Martin (PPG Industries, Inc.) - vss163



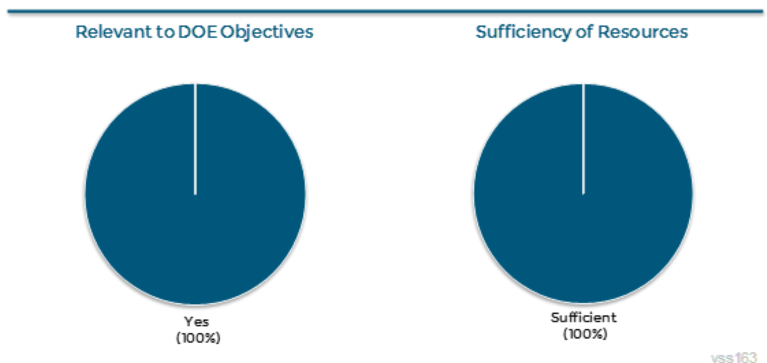


Figure 1-41 Advanced Bus and Truck Radial Materials for Fuel Efficiency: Justin Martin (PPG Industries, Inc.) - Vehicle Systems

Presenter

Justin Martin, PPG Industries, Inc.

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that it seems like a good approach. There is lots of background experience to draw on and the tools and plans are in place to proceed and be successful.

Reviewer 2:

The reviewer stated that the objective of this task is to design, develop, and demonstrate fuel efficient and safety regulation-compliant tire filler technologies with the expected outcome to achieve natural rubber truck and bus radial tires with an overall fuel efficiency improvement of 4-6%, while maintaining or improving tear strength and tread wear. The focus is to develop a method to controllably and uniformly disperse silica fibers into rubber formulas, develop a new, surface-modified silica technology that reduces rolling resistance by at least 60% in the lab compared to current carbon black technology, and the development of new rubber blends optimized for rolling resistance, tear strength, and tread wear performance. The reviewer noted that a significant challenge for truck and bus tires is that natural rubber contaminants are believed to interfere with in situ coupling required to effectively disperse silica, thereby yielding poor filler dispersion, tire performance, and processing. The approach involves investigating the ability of Agilon passenger tire products to overcome the natural rubber contaminant problem which has been researched and published. The reviewer indicated that the overall approach includes controlling dispersion (understanding how different silica surface chemistries and surface areas or linked to performance), development of new tread compounds (using previous results to reduce rolling resistance by at least 60% with no degradation in hardness, tear strength, and tread wear), and ultimately optimizing formulas for on-tire performance (select final rubber compound formulations for tire builds for independent testing by DOE). This is a very sound and logical approach to achieving the project objective and addressing associated challenges.

Reviewer 3:

The reviewer stated that the approach of trying new filler materials is sensible. The reviewer indicated some uneasiness about the target being truck tires. Even if the team means only Class 8 trucks (very unclear), tires for different uses-- high speed versus low, cold versus hot climate, heavy load versus lighter, are likely to require different properties. Perhaps the budget was too small to address a variety, but the primary target should have been identified.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer indicated that several appropriate compounds were fabricated and examined. Adequate dispersion of silica in natural rubber blends was observed.

Reviewer 2:

The reviewer noted that the project is a recent start (October 2014) but has already achieved some key accomplishments. Specifically, surface energies of key rubber compounds have been calculated where the surface energy/polarity measurement is critical to understanding how to disperse fillers in polymer compounds. The reviewer stated that 12 silica materials have been synthesized to date and a variety of surface energies created. Most important, early rubber compound testing shows promising results with improvements of 47% in rolling resistance, 18% in wear resistance, and equivalence in hardness for treated silica versus the silica control. The reviewer stated that overall, strong technical accomplishments were achieved early in the project.

Reviewer 3:

The reviewer stated that the project is showing good progress toward the 60% rolling resistance (RR) target. The reviewer suggested having an intermediate metric to track progress on RR reduction.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer indicated that the project partners are PPG Industries, Bridgestone Americas Tire Operations, and Augustine Scientific – a lean, but sufficient team. It may be good to consider other project partners should intransigent technical issues arise and confound resolution.

Reviewer 2:

The reviewer stated that the key collaborator is, of course, the tire manufacturer. The analytic lab is also important. The reviewer noted that it would have been desirable to add a trucking company that might have been able to advise on the different types of use conditions the final tires would need to handle. The reviewer stated being convinced that one size does not fit all trucks and buses.

Reviewer 3:

The reviewer stated that it was not completely clear what Bridgestone brings besides consulting, but perhaps that is enough.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that it looks like a good plan with intermediate measures and tests to filter choices and show progress.

Reviewer 2:
The reviewer indicated that the proposed future work is very well detailed at the higher levels (optimizing silica materials and development of compatible rubber compounds) and identifying key tasks with associated milestones. Additionally, a discussion of the key remaining challenges and potential solutions is provided. The reviewer stated that this provides a sense that the project is well planned and thought out, with potential future obstacles already identified and solution pathways identified.

Reviewer 3:
The reviewer stated that the future work will basically optimize what the project team has already done and try to understand how processing and formulations change the results.

Question 5: Relevance - Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer indicated excellent relevance, if this project delivers production-capable technology, fuel consumption will be directly reduced.

Reviewer 2:
The reviewer stated that this project supports overall DOE objectives of petroleum displacement because heavy-duty trucks and buses account for a large portion of petroleum use in the country and the contribution of tire RR to petroleum usage is significant, second only to aerodynamic effects.

Reviewer 3:
The reviewer stated that obviously if truck efficiency can be improved 4-6%, petroleum is saved. It is unclear how this work will actually demonstrate these savings.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer stated that this project is 25% cost shared. Resources for the project are sufficient.

Reviewer 2:
The reviewer emphasized that is was hard to evaluate from information provided.

Reviewer 3:
The reviewer stated that it was hard to comment, but noted that DOE is funding a very large portion (75%) of the overall project and asked why the partners are not contributing more.

Evaluate VTO Benefits (BaSce): Neeraj Shidore (Argonne National Laboratory) - vss164

Presenter

Aymeric Rousseau, Argonne National Laboratory.

Reviewer Sample Size

A total of four reviewers evaluated this project.

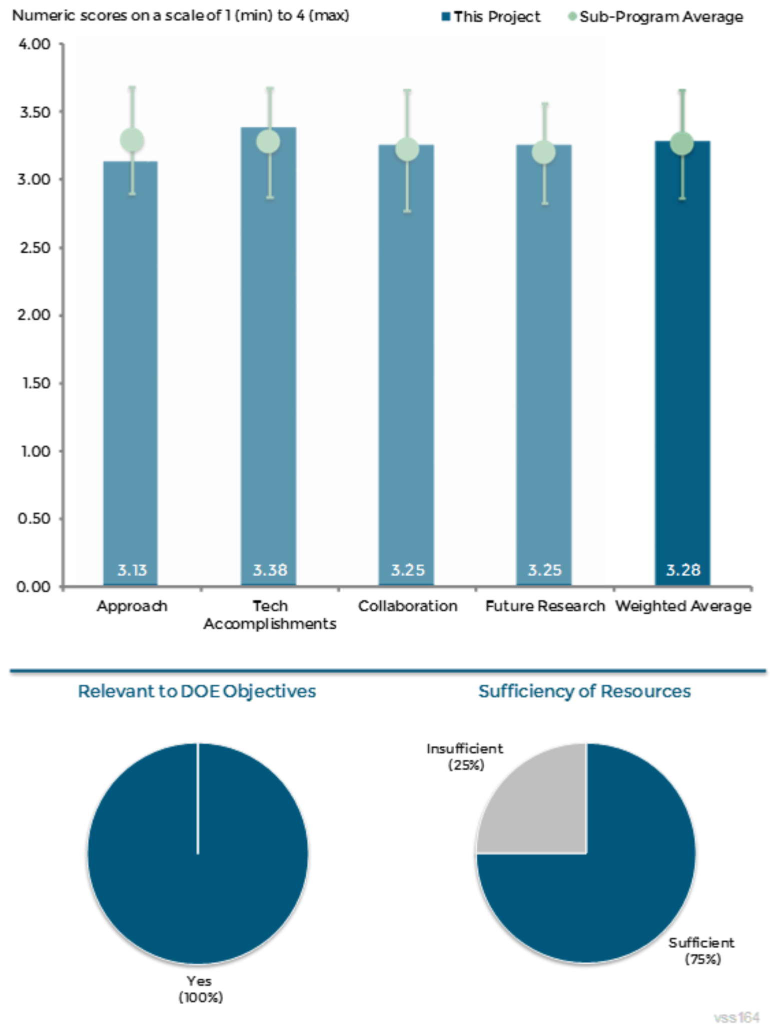


Figure 1-42 Evaluate VTO Benefits (BaSce): Neeraj Shidore (Argonne National Laboratory) - Vehicle Systems

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that the simulation approach presented is outstanding in examining the fuel consumption and vehicle cost in coming decades.

Reviewer 2:

The reviewer noted an interesting project that will eventually grow with time. Adding new PT combinations/new technologies and then simulating benefits of all the combinations to determine which make sense and which do not, is a computational nightmare but assuming no limitation on computing power - is achievable.

Reviewer 3:

The reviewer stated that scaling up the number of simulations by an order of magnitude or more appears to have been accomplished quite effectively. As the authors point out in the presentation, dealing with the large quantity of data requires very robust quality assurance (QA)/quality control (QC), and in such cases, usually, one can only account for problems that have been encountered before. The reviewer questioned how to address problems that have never been seen before in an automated QA/QC process. The reviewer also questioned, on a separate note, how to separate out the benefits of VTO funding, as distinct from advances that might have taken place even without VTO funding.

Reviewer 4:

The reviewer stated that the information was pertinent, but poorly displayed.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer stated that the results obtained help to overcome the critical barriers to reducing consumption of petroleum fuels and promoting commercialization of innovative vehicle technologies.

Reviewer 2:

The reviewer indicated that the novelty of using IAV to determine the baseline and then variance from this point is a useful way of normalizing technologies so that their true benefit can be assessed. The component sizing versus cost benefit is a strong achievement.

Reviewer 3:

The reviewer indicated that good progress appears to have been made in developing methods for handling large quantities of results; however, this remains the Achilles heel - see previous comment. The reviewer stated that the graphs on Slide 11 are confusing and the probability in the two graphs should add up to one. The reviewer indicated that Slide 14 is confusing as well - the second graph shows diesel HEVs having lower fuel consumption than gasoline HEVs, but the statement above the graphs makes the opposite claim. The reviewer said that in the technical accomplishments slides, a short explanation of why the results are what they are, would be very helpful. The reviewer stated that significant amounts of data are being processed to generate these graphs, and putting a reasonable amount of effort into understanding and explaining the reasons for the trends (even the slightest variation from expected behavior) would lessen the likelihood of bad results slipping through the QA/QC process.

Reviewer 4:

The reviewer stated that it was somewhat difficult to follow the flow and solutions. Once it was explained it made more sense, needed verbal guidance.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer saw no problem here.

Reviewer 2:

The reviewer stated that the partners still appear to be predominantly from within DOE. The strength of this program should be shared and made available for others to use. The reviewer discussed with the presenter that while the information and data from this project is available, one unfortunately must know that it is there, and then go look, as it is not publicized in any way that the reviewer could determine.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer would like to see this project reach into the MD and HD environment. Here the complexities are much greater and a tool like this could be of significant benefit to both OEMs and Tier 1 suppliers. The reviewer would be interested to see if a slimmed-down version of this could be used as an ordering tool to assist customers in their technology selection, recognizing the complexity of the MD/HD world.

Reviewer 2:

The reviewer stated that life-cycle cost is one of the most important factors for the customer in selecting future vehicle technologies. The principal investigator (PI) should consider the cost of home charging systems for EVs and PHEVs as most customers will have in-house charging systems in the future.

Question 5: Relevance - Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that the study has supporting information to show the relevance.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer remarked resources were poorly displayed.

Design and Implementation of a Thermal Load Reduction System in a Hyundai PHEV to Improve Range: John Rugh (National Renewable Energy Laboratory) - vss165

Presenter

John Rugh, National Renewable Energy Laboratory.

Reviewer Sample Size

A total of four reviewers evaluated this project.

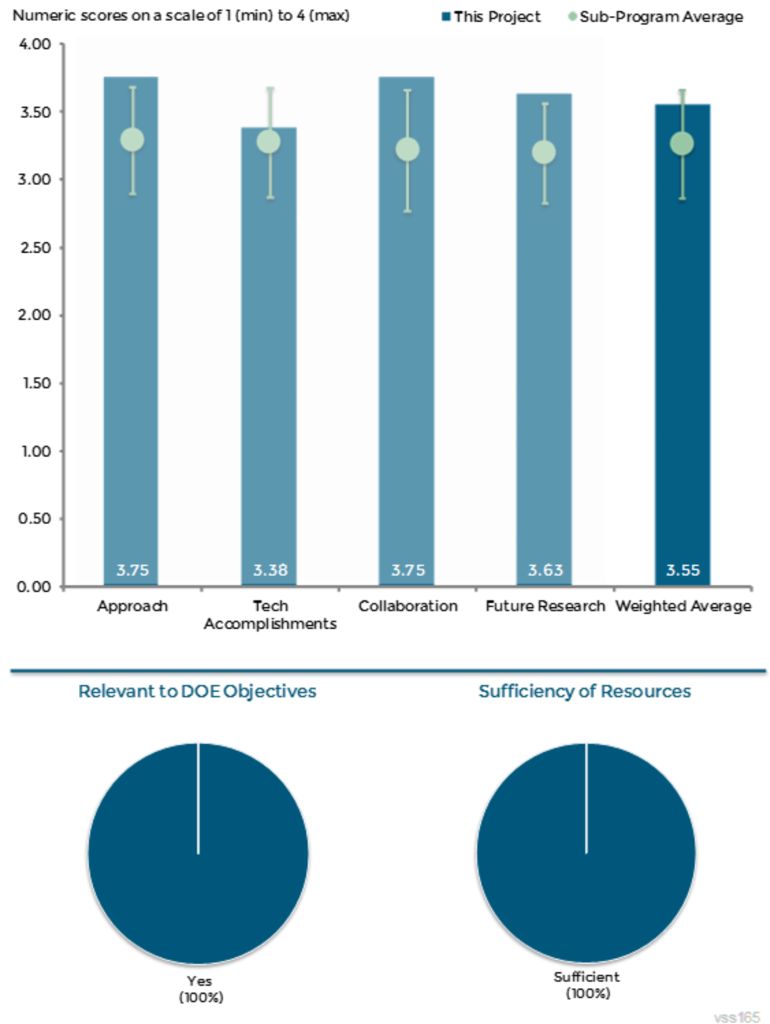


Figure 1-43 Design and Implementation of a Thermal Load Reduction System in a Hyundai PHEV to Improve Range: John Rugh (National Renewable Energy Laboratory) - Vehicle Systems

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer noted a well-organized follow-on to previous work

Reviewer 2:

The reviewer was excited to see the results of this project. Approach looks long, strong and two phases seem appropriate for planning. The reviewer stated that it builds on the strong skill set NREL has on this after completing the truck project.

Reviewer 3:

The reviewer stated that the goal of the project is to increase the grid-connected electric drive vehicle range by 20% during operation of the climate control system over the standard vehicle configuration by reducing vehicle thermal loads. The reviewer stated that thermal loads can be highly detrimental to the range of EVs in cold (especially) and hot ambient temperatures. The two-phase approach of this task with Phase 1 being led by NREL and Phase 2 by Hyundai America including design and development under phase 1 and integration and validation under phase 2 is sound. The reviewer noted that both phases include testing and analysis. Phase 1 will be conducted on a prototype and Phase 2 on production Hyundai Sonata PHEVs. The reviewer stated that a broad cross section of technologies (often leveraging previous work) are being examined including insulation, solar reflective paint, solar control glass and films, heated and cooled seats, door glass defrosters/ defoggers, and grid-connected preconditioning. It is not clear whether advanced HVAC systems are being considered as part of this project, probably not. The overall approach and sequencing including the hand-off after phase 1, as well as the scope of technology considerations is well considered.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer indicated it is early in project and looks forward to Phase 2 results.

Reviewer 2:

The reviewer stated that the project seems to have a good start and a good team in place.

Reviewer 3:

The reviewer stated that the project is new start for fiscal year (FY) 2015 and as such has a relatively limited number of accomplishments. Business/legal agreements with partners have progressed, a vehicle platform (Hyundai Sonata) has been chosen, and a preliminary summer test plan/approach has been identified. The reviewer indicated that this summer’s test plan includes splitting the effort into a two-phase air conditioning test (pull-down and steady state) which is expected to increase repeatability and improve determination of technology impact on HVAC loads. Overall, given the early stage of the project, an acceptable list of accomplishments.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that having Hyundai as a partner in the project will prove concepts once in the demonstration phase.

Reviewer 2:

The reviewer indicated good work getting OEM involvement.

Reviewer 3:

The reviewer noted a good set of collaborators.

Reviewer 4:

The reviewer stated that the extent of collaboration and coordination with other entities is excellent, including a vehicle OEM (Hyundai), a well-regarded climate control system supplier (Halla Visteon), and a technology supplier for each specific technology area. The reviewer stated that there are no obvious gaps in the overall team structure.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that quantifiable results from actual test will be very valuable. Should consider hot weather testing in a desert environment rather than at NREL.

Reviewer 2:

The reviewer stated that the proposed future work is covered adequately at a high level outlining the general task activities to be conducted. It would be beneficial if additional detail were provided as to specific task activities, especially ones which may be more critical (go/no-go milestone determinative) or challenging. Additionally, the reviewer stated that it would be beneficial to provide some insights into alternative strategies/options should current ones being considered not pan out either technologically or from an economic standpoint.

Question 5: Relevance - Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that the energy required for ancillary systems needs to minimize to provide more energy for propulsion.

Reviewer 2:

The reviewer noted excellent support to EV range achievement per EV Everywhere goals.

Reviewer 3:

The reviewer believed the project does support DOE goals. EVs and PHEVs need new understanding of these types of analyses, heat loading and the associated solutions, and using electric power as much as possible to propel the car.

Reviewer 4:

The reviewer stated that this project supports DOE objectives of petroleum displacement, as a significant barrier to continue market expansion of PHEVs is range reduction resulting from climate control loads, especially in cold weather. By reducing the impacts of climate control loads, the size of the battery and climate control system can be reduced (lowering cost) or kept the same achieving greater driving ranges and consumer acceptance.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that this project has a 20% cost share, which indicates respectable industry commitment. Resources for this project are sufficient.

Advanced Transmission Selection to Provide Accurate VTO Benefits: Neeraj Shidore (Argonne National Laboratory) - vss166

Presenter

Neeraj Shidore, Argonne National Laboratory.

Reviewer Sample Size

A total of four reviewers evaluated this project.

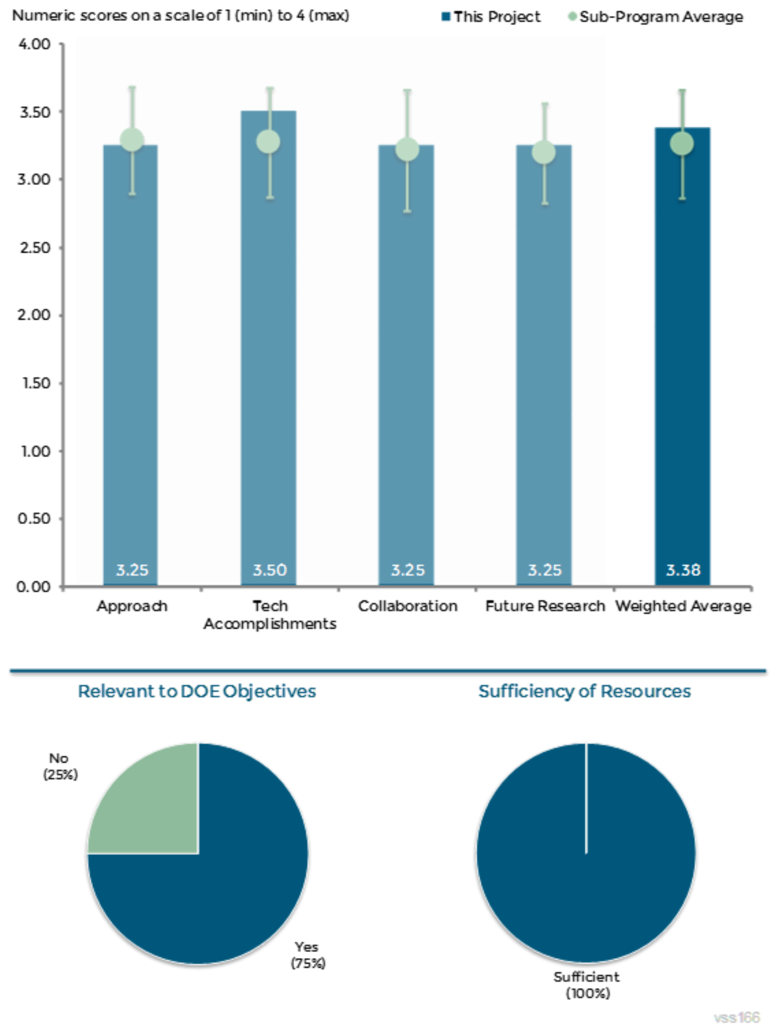


Figure 1-44 Advanced Transmission Selection to Provide Accurate VTO Benefits: Neeraj Shidore (Argonne National Laboratory) - Vehicle Systems

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer noted that the approach to enhancing transmission selection to merge with control optimization and vehicle sizing process is very good. Previous work of updating automatic transmission and shifting algorithms in Autonomie and development of detailed dual-clutch transmission (DCT) and continuously variable transmission (CVT) models have provided a good basis for accomplishing this year's and future activities.

Reviewer 2:

The reviewer stated that the modeling and validation approach for implementing transmission models in Autonomie is well done. There are some inherent modeling limitations in capturing characteristics of these complex systems.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer noted that the progress has been excellent. Models are very reasonable in results produced.

Reviewer 2:

The reviewer stated that the technical accomplishments have been very good, including the development and validation of advanced transmission models and showing that shift parameter optimization can result in significant fuel economy improvements in conventional powertrains.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that the project leverages data from various sources where available. Inherent limitations are imposed by industry reluctance to share information.

Reviewer 2:

The reviewer stated that the collaboration and coordination in this project are very good. Technical guidance provided by the automotive manufacturers is very useful to the success of the project. The reviewer indicated that the data from Argonne's APRF is essential to the success of the project.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer noted that the proposed future work is directionally correct. Co-optimization may yield some incremental benefits.

Reviewer 2:

The reviewer stated that the plan of future activities to expand optimization techniques to evaluate benefits of VTO technologies is very good. Including real-world driving cycles in the evaluation VTO technologies will provide needed additional insight into the technologies.

Question 5: Relevance - Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer indicated that it enables better modeling of systems for DOE technology assessments. This allows a more accurate picture of what is needed to achieve DOE objectives.

Reviewer 2:

The reviewer stated that this project definitely supports the overall DOE objectives of petroleum displacement. The development of algorithms for proper transmission selection is essential to evaluate the impact of vehicle technologies on fuel displacement and cost of advanced vehicles. The reviewer stated that the evaluation of VTO technologies requires a proper transmission selection and optimization which this project provides.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer indicated that resources appear adequate.

Reviewer 2:

The reviewer stated that resources appear adequate to complete the project.

Integrated Network Testbed for Energy Grid Research and Technology Experimentation (INTEGRATE): Brian Hunter (National Renewable Energy Laboratory) - vss167

Presenter

Brian Hunter, National Renewable Energy Laboratory.

Reviewer Sample Size

A total of four reviewers evaluated this project.

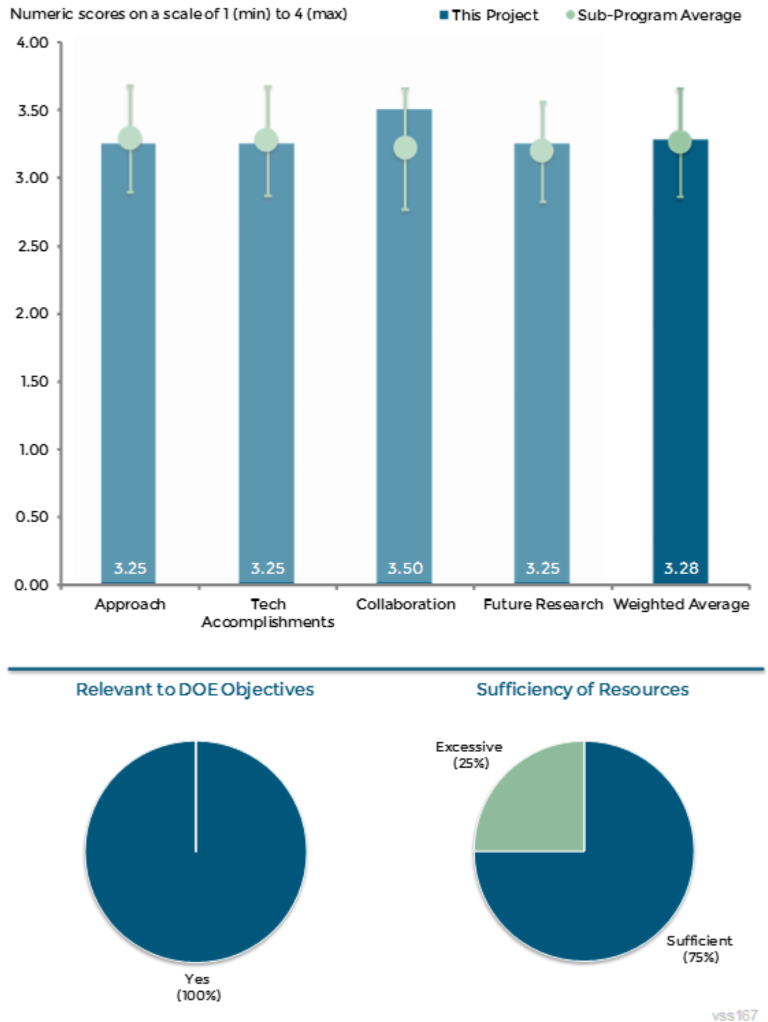


Figure 1-45 Integrated Network Testbed for Energy Grid Research and Technology Experimentation (INTEGRATE): Brian Hunter (National Renewable Energy Laboratory) - Vehicle Systems

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer noted an excellent technical approach to establish operational feasibility and standards. Future work should consider regulatory and social changes required to support adoption.

Reviewer 2:

The reviewer stated that it was initially unclear how NREL is participating on the INTEGRATE project according to the presentation; however, after speaking with the presenter, it became clear that NREL is offering their facilities to the project. The reviewer concluded that INTEGRATE as a project is an appropriate activity to test out standards issued as part of the Grid Integration Initiative to evaluate how thorough and complete existing standards are, as well as to shine a light on gaps in these standards.

Reviewer 3:

The reviewer stated that it appears that 90% or more of the work done to date is in reviewing proposals and selecting the awardees. Very little information was provided about the selection process although the reviewer was told that more than 40 proposals were reviewed, a massive effort. The reviewer emphasized that it is not clear if reviewers are reviewing the selection process or the awarded projects. Most of the projects have not started yet, so it is difficult to review them and not enough information on the individual projects was provided to evaluate.

Reviewer 4:

The reviewer stated that this project has three primary components: connected devices, communication and control systems, and integrated systems with a focus on ensuring the seamless integration of clean energy technologies into the electrical grid. The reviewer said that on the surface this approach seems reasonable, but what seems to be missing is a clear vision (or at least presentation thereof) on how all this comes together at the end of the project and fits into the realities of the marketplace and existing standards and codes environment. For example, under Approach/Strategy topic area 2, it says “INTEGRATE projects will design, build, and test a flexible, open-source, consensus standards-based communications, information, and communication (CIC) infrastructure ....” The reviewer stated that it is not clear exactly what this means and how an open-source, consensus standards-based system would be established given the proposed 18-month project duration juxtaposed with the notoriously slow standards development process and that some related standards are only currently in progress. Additional information elucidating the processes and pathways of how all the project pieces come together at the end, more detailed information with regard to the role of standards development organizations, and the final project outcomes would be very helpful.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:
The reviewer noted good progress in team selection and integration. Early in project.

Reviewer 2:
The reviewer stated that the project is 5% complete and is in the planning stage. That said, it would be good to see a proposed timeline, activities and deliverables for each topic area.

Reviewer 3:
The reviewer stated that this project is a relatively new start (2014) with essentially all the accomplishments being contractual in nature; reasonable progress has been achieved in this regard.

Reviewer 4:
The reviewer indicated that most of the work has not yet begun. The process of selecting and putting contracts in place is difficult but not enough information was provided on the selection process to determine its quality.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer noted that a large consortium of partners is involved in the INTEGRATE project in order to evaluate these standards. We will see in the future how the collaboration pans out.

Reviewer 2:
The reviewer stated that the new facilities at NREL support all project requirements. Should consider coordination with INL to address cyber security of systems.

Reviewer 3:
The reviewer stated that although not all of the 40+ proposals were included, it is clear that a very high level of collaboration is being done. The reviewer expressed disappointment that no utilities were selected for award.

Reviewer 4:
The reviewer stated that so far, there is a respectable number and broad cross section of collaborators in the project areas in which awards have been made. The collaborators identified appear appropriate to the tasks at hand. The reviewer indicated that it is important to stay in close contact and coordination with the codes and standards development community. A very strong element is the high level of cost share for the project, nearly 50% indicating strong commercial interest.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer stated that most of the work is yet to be done. The reviewer is expecting significant accomplishments to be reported next year. The reviewer suggested that each of the awarded projects are reviewed individually and not as a group.

Reviewer 2:
The reviewer stated that 95% percent of the project lies ahead. The execution of the three topic areas appear to cover the important aspects of testing out the connected grid.

Reviewer 3:
The reviewer stated that for future project scope, consider business model required to support adoption.

Reviewer 4:
The reviewer stated that the proposed future research does not clearly identify the strategy and activities moving forward. Technologies will be installed and evaluated at the Energy Systems Integration Facility (ESIF) location at NREL, but with the exception of the University of Delaware project, little specific technical detail is given as to what the large task activities will be within each area. The reviewer questioned how all these activities coalesce at the end and fit seamlessly into the realities of an evolving grid and transitioning marketplace.

Question 5: Relevance - Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer stated, yes, this project contributes to the operations of the connected grid, in which renewable energy sources are harmonized with smart appliances and consumers, also including EVs.

Reviewer 2:
The reviewer noted that the project is relevant to DOE objectives of petroleum displacement as the use of electric-drive vehicles will reduce petroleum use and the ability to synergistically tie EVs to the grid (both as V2X services and coordinating with load curves of renewable energy resources) is important to expanding the value proposition of EVs to the consumer.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer suggested consider adding a cyber-security resource.

Reviewer 2:
The reviewer stated that the resources for the vehicular element of this project seem somewhat excessive. The two main project elements for vehicles include “characterizing the ability of V2X assets to increase hosting capacity of the grid and provide grid services” and “support open, practical, interoperable platforms in a way that enables renewable power and sustainable transportation technologies.” The reviewer indicated that other entities are looking at similar things (such as ANL and SDOs) and it is important to be fully cognizant of and coordinate with them upfront and on an ongoing basis to eliminate duplication/overlap of activities. It may be a good idea (it is not clear whether this is intended) to look at the services that could be provided to the home by EVs as part of this project (such as during emergency power outages), as in some ways this may be a more viable and tangible attribute in the minds of potential EV consumers.

Accessory Loads Analysis: Richard Carlson (Idaho National Laboratory) - vss168

Presenter

Richard Carlson, Idaho National Laboratory.

Reviewer Sample Size

A total of four reviewers evaluated this project.

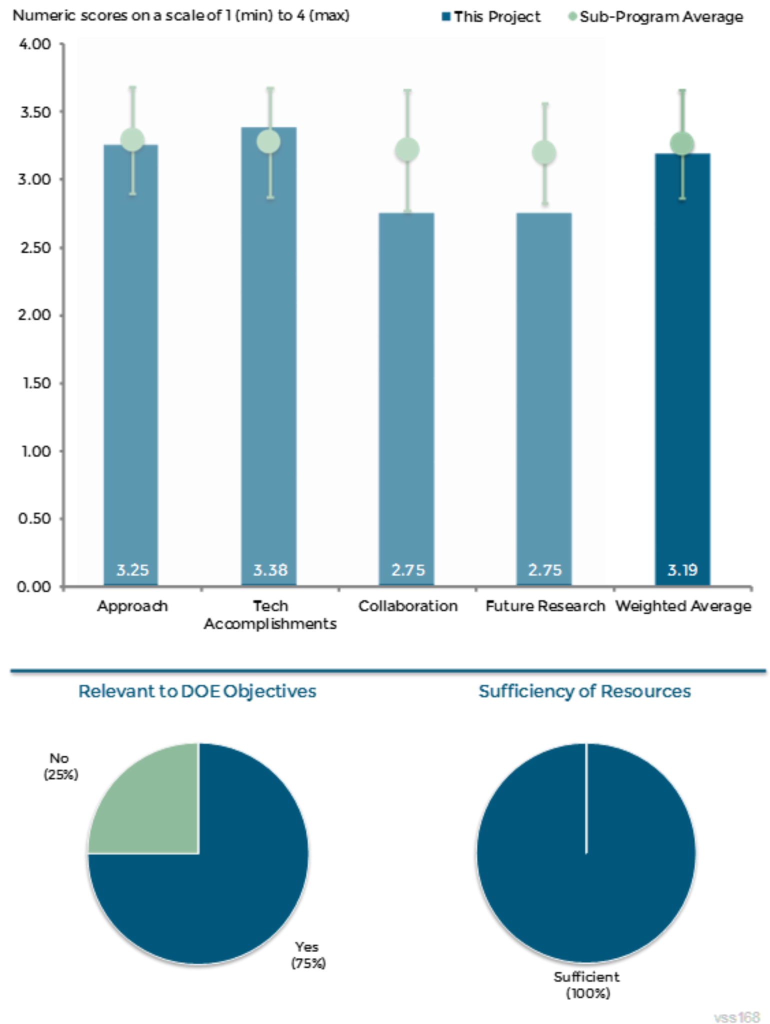


Figure 1-46 Accessory Loads Analysis: Richard Carlson (Idaho National Laboratory) - Vehicle Systems

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that the project follows standard test procedure. The approach could be updated as the project progress.

Reviewer 2:

The reviewer stated that the approach taken is good, but desired to see additional vehicles included, along with measuring individual loads for a given common feature.

Reviewer 3:

The reviewer suggested the PI might want to consider the distance-specific energy consumption of auxiliary systems, which will help research community to better understand the percentage of energy consumed by auxiliary systems.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer noted that the project is on track. This could be a starting point for other data generation, collection, and analysis to further evaluate this area. Also, it could expand to other types of vehicles.

Reviewer 2:

The reviewer stated that the accomplishments and progress are good, but wanted to see data broken down by features and not the total aggregate.

Reviewer 3:

The reviewer stated that the data are important for industry and research community in evaluating the auxiliary load of LDVs.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer stated that additional vehicles and involvement from OEMs with technical support will enhance the data resolution and accuracy.

Reviewer 2:
The reviewer noted that more OEMs should be involved. Larger vehicles such as full-size U.S. cars should be evaluated.

Reviewer 3:
The reviewer indicated that the role of partners in this report is not explained.

Reviewer 4:
The reviewer noted that this information appears to lack relevance to anyone other than the OEMs. Even if this is exclusively funded by industry, some explanation of how the outcome will be beneficial to consumers should be provided.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer stated that there is more potential for future work in this area.

Reviewer 2:
The reviewer stated that future relevant research may be the impact HEVs and EVs.

Reviewer 3:
The reviewer would like to see data at the component and feature level; and not just the aggregate vehicle level. This will allow comparison of the relative loads.

Reviewer 4:
The reviewer stated that distance-specific auxiliary load consumption should be reported in the future.

Question 5: Relevance - Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer noted this project will help to better understand the energy consumption of auxiliary system.

Reviewer 2:
The reviewer stated that this work could have impact in an area that is important for the development of advanced technology systems that could improve vehicle fuel economy,

Reviewer 3:
The reviewer noted that this research appears to be in the interest of the OEMs alone.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer stated that the project has sufficient resources.

PEV-EVSE Interoperability Project: Richard Jacobson (Intertek) - vss169

Presenter

Jeffrey Wishart, Intertek.

Reviewer Sample Size

A total of five reviewers evaluated this project.

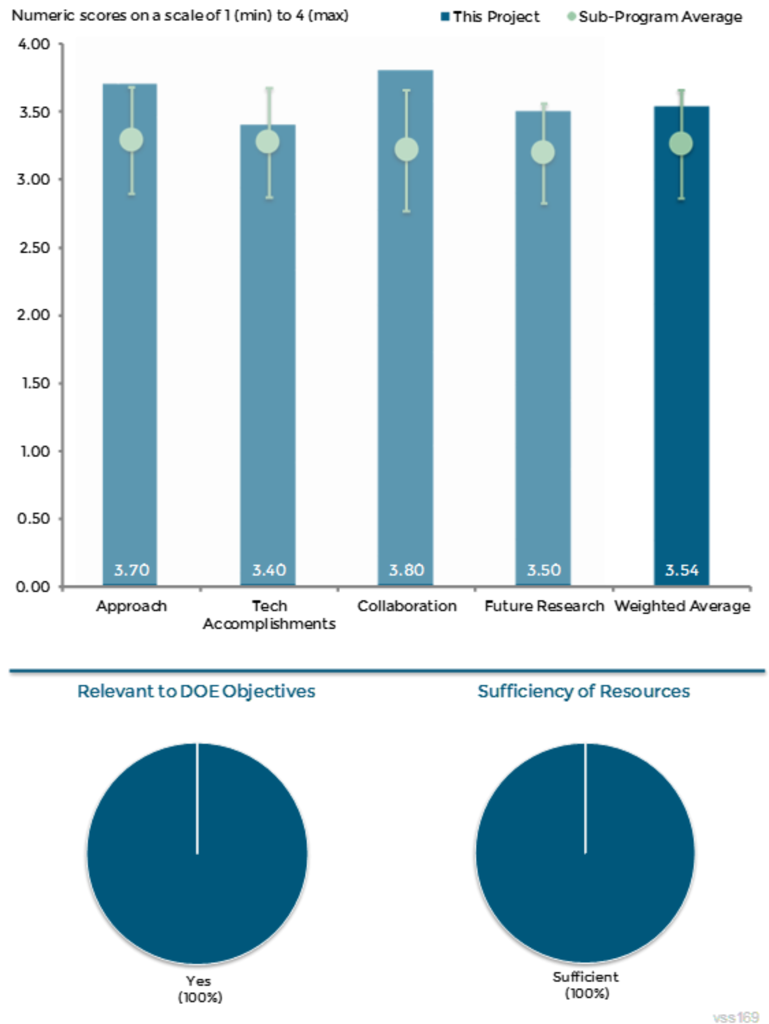


Figure 1-47 PEV-EVSE Interoperability Project: Richard Jacobson (Intertek) - Vehicle Systems

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer indicated that the one year project was on target and under budget, EVSE evaluations complete.

Reviewer 2:

The reviewer indicated a systematic vehicle testing approach that tested a large number of combinations and EVSE equipment in a controlled setting. The reviewer stated that this type of effort is critical as second-generation EVSEs are being developed and new standards are being created regarding this equipment.

Reviewer 3:

The reviewer indicated that the overall approach was straightforward and logical. In order to see how the standard worked, the team tried to use it on as many vehicle and EVSE pairs as possible. The reviewer emphasized that it makes perfect sense to try out the standard under real conditions before promulgating it.

Reviewer 4:

The reviewer stated that the approach involved testing a matrix of PEVs and EVSE charging infrastructure, which seems like the most effective way to evaluate interoperability and inform refinement of the J2953 testing standard. Anecdotal comments shared by the presenter on project experience include observations of break-in/wear on the components as well as an experience curve for the technician conducting the testing that were not necessarily anticipated. So perhaps planning for how to address such a break-in period could be one minor way to improve the approach were this project to be repeated.

Reviewer 5:

The reviewer stated that the approach is sound and is a comprehensive approach to testing the interoperability between EV and EVSE. The project expands upon J2953 test protocols to further define failure modes and provides a better understanding of failure mechanisms.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:
The reviewer stated that the project was brought to completion highlighting both successful EVSE communication and failures.

Reviewer 2:
The reviewer stated that over 2,500 EVSE/vehicle pairs were tested on a uniform basis. The testing method and software were evaluated and provided to equipment/vehicle manufacturers as appropriate. The reviewer stated that the results were interesting, in that not all pairs worked, so changes in the testing procedure and/or hardware had to be developed.

Reviewer 3:
The reviewer stated that initial results have identified vehicle, equipment and test procedure issues that could not have been discovered without this effort. If electrified mobility is the long-term goal, this type of effort should precede next-gen e-mobility infrastructure development.

Reviewer 4:
The reviewer stated that work was completed on time and under budget. The technical accomplishments of this project will help further the research of EVs within DOE's VTO.

Reviewer 5:
The reviewer noted that the presented accomplishments focused on completion of alternating current (AC) Level 2 compatibility testing between the range of vehicles and charging equipment. This testing revealed some issues, which were shared with the individual manufacturers whose equipment was involved, and an aggregate, anonymized report was created and published. The reviewer noted that it would have been nice to have the presentation include some additional details and findings from the test report.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer indicated that the collaboration included the most important players in the field, both from the national laboratory side and industry.

Reviewer 2:
The reviewer noted a very good mix of vehicles and hardware represented in this study.

Reviewer 3:
The reviewer stated that collaboration with ANL on the automated test procedure was excellent. Collaboration with SAE J2953 was good and supplemented ongoing work within that standards committee.

Reviewer 4:
The project involved extensive collaboration and coordination with manufacturers of the vehicles and charging equipment, with SAE and particularly the J2953 test procedure development committee, with ANL for testing automation software development and equipment, and with INL for overall AVTE program management and publication of the project report. The reviewer stated it is unfortunate that the results are only published in an anonymized format, but understandable if that was what the various manufacturers required in order to participate.

Reviewer 5:
The reviewer emphasized that sufficient laboratory and organizations; would have been nice to have more OE involvement.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that the team proposes to expand the scope to include fast charging and Tesla systems, which is important because of Tesla's pivotal market position and influence. It will be key to making sure there is compatibility among EVSE types. The reviewer emphasized that it will be necessary and challenging to develop a standard for testing these products.

Reviewer 2:

The reviewer stated that the proposed future work focuses on direct current (DC) charger interoperability testing, which represents a natural extension of the Phase 1 work.

Reviewer 3:

The reviewer stated that the focus on DC fast charging was appropriate and clear. Project could also add some MD/HD and/or commercial focus to look at these users/systems.

Reviewer 4:

The reviewer questioned whether the number of high-power level chargers warranted a similar test effort, or tighter equipment standards.

Question 5: Relevance - Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer noted that it directly supports EV infrastructure development, and consumer acceptance of technology.

Reviewer 2:

The reviewer stated again, it is pretty simple. EVs are never going to gain significant market share if you cannot charge them reliably everywhere, so having standard, reliable chargers are key to petroleum displacement via electrification.

Reviewer 3:

The reviewer stated, yes, it helps develop and advance the state of the art for electric-drive vehicles.

Reviewer 4:

The reviewer stated that interoperability of vehicles and charging infrastructure will be critical to achieving reliability and positive consumer experiences with the technology. This seems like a very appropriate role for government support to ensure that interoperability is successful, that the testing standard is as robust and effective as possible, and that individual manufacturers need not incur the redundant expense of each conducting this testing separately.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer noted that it appears that the project team has accomplished its work quite well within the allocated modest budget, so the funding was sufficient. The reviewer is confident that the next phase will also be appropriately budgeted.

Reviewer 2:

The reviewer indicated that the resources seem sufficient for conducting the testing described.

Reviewer 3:

The reviewer said project was completed with sufficient budget.

Lessons Learned about Workplace Charging in The EV Project: John Smart (Idaho National Laboratory) - vss170

Presenter

John Smart, Idaho National Laboratory.

Reviewer Sample Size

A total of four reviewers evaluated this project.

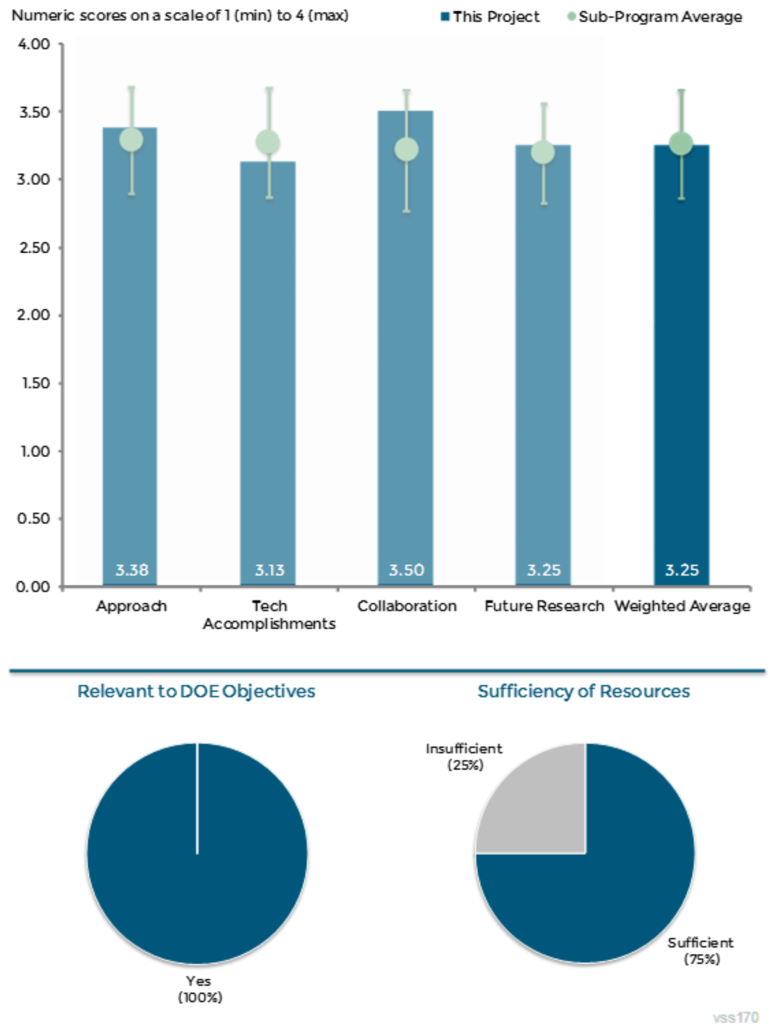


Figure 1-48 Lessons Learned about Workplace Charging in The EV Project: John Smart (Idaho National Laboratory) - Vehicle Systems

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer noted great work on a very small budget. The approach is solid.

Reviewer 2:

The reviewer stated that the project seeks to shed light on any existing barriers to EV adoption and starts to identify policies that employers can implement to improve EV charging usage at workplaces. The reviewer indicated that the Phase II revisions led to a more actionable deliverable targeted to employers to use when designing and deploying their EV charging infrastructure.

Reviewer 3:

The reviewer stated that while the original project as conceived was good, there appears to have been insufficient data to carry through and complete the original scope of the project. The accomplishment slides appear to indicate that at least some of the data were acquired as answers to survey questions, and as with all surveys, the reviewer questioned what measures were taken to improve the accuracy of the collected data. The reviewer also asked if the drivers were asked to maintain detailed logs.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer stated that this is a very important issue for DOE to understand. The implications are very broad as utilities and others look at the business viability for workplace charging.

Reviewer 2:

The reviewer noted that the project is well positioned to deliver the lessons learned document by mid-2015. Some of the data analyzed is inconclusive, such as which policy factors lead to higher EV charging (Slide 18) as well as which types of drivers would be most likely to make use of charging infrastructure (Slide 17). The reviewer indicated that it seems more investigation is needed to be able to make concrete solutions regarding lessons learned.

Reviewer 3:

The reviewer stated that the PI appears not to have had access to key pieces of information that could have helped improve the quality of the results – the cost of electricity, when users had to pay for the charging, for instance.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted a very impressive list of companies that were involved. The information will be very valuable to them.

Reviewer 2:

The reviewer questioned if it would have helped to leverage the research done in some of the universities or other national laboratories (LBNL, for instance), and leverage their expertise in these areas.

Reviewer 3:

The reviewer stated that the project seems to have good collaboration with EV project partners to support the data collection. The reviewer would like to see collaboration with partners who will be customers of the lessons learned document and how this report will be disseminated.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that the completion of the lessons learned document wraps up this project. It would be recommended to continue this investigation to dive deeper into an analysis on the effectiveness of policy choices at employers, including the designing of experiments to see how the absence or presence of a specific policy option impacts charging usage.

Reviewer 2:

The reviewer stated that larger sample sizes are needed for the studies, and as the author notes, the study only looked at early adopters. The reviewer stated that one important question to answer would be how we can extrapolate the results of studies that include (perhaps) only the EV-believers to the general public. It seems that this study may need to step beyond just a purely statistical analysis and venture into human behavioral aspects as well.

Question 5: Relevance - Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that this is a critical issue to understand the impact on the grid and climate change.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer noted that the data collection phase appears to be complete, and the only remaining tasks appear to be documentation.

Reviewer 2:

The reviewer noted that this issue should get much more attention.

eVMT (Electric Vehicle Miles Traveled): Richard Carlson (Idaho National Laboratory) - vss171

Presenter

Richard Carlson, Idaho National Laboratory.

Reviewer Sample Size

A total of four reviewers evaluated this project.

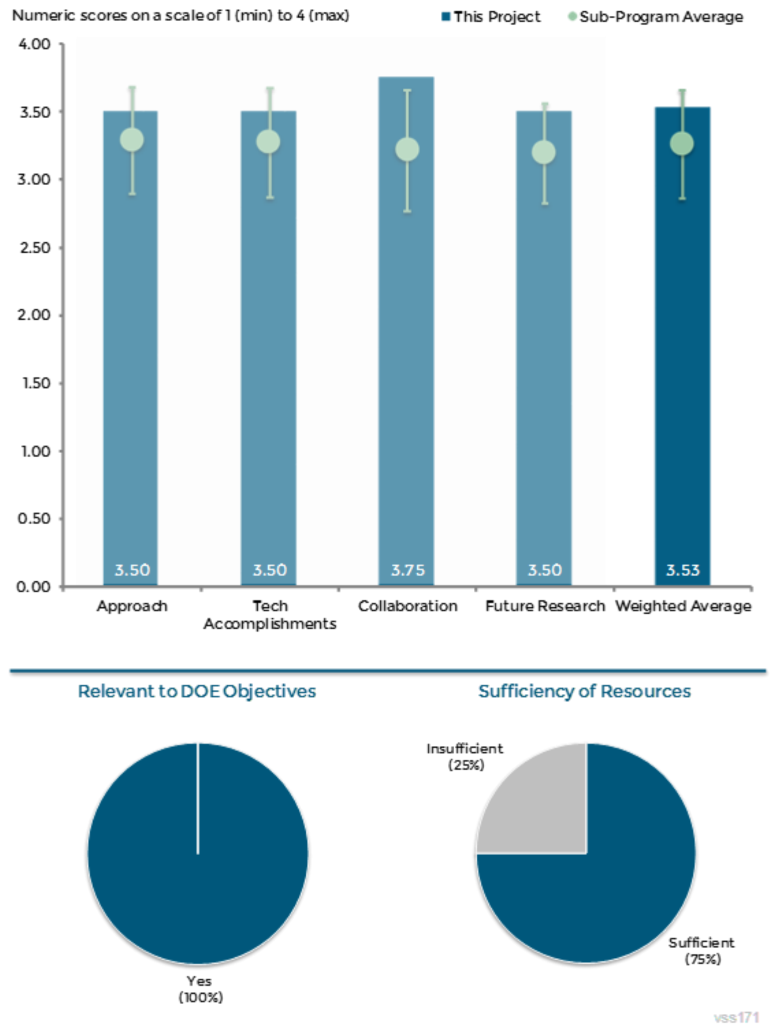


Figure 1-49 eVMT (Electric Vehicle Miles Traveled): Richard Carlson (Idaho National Laboratory) - Vehicle Systems

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that the approach of analyzing data of 21,600 vehicles across a wide region of the U.S. for electric vehicle miles traveled (eVMT) based on fuel economy label and vehicle average charge sustaining fuel consumption is very good and will help eliminate the barrier of the lack of real-world data from electric-drive vehicles.

Reviewer 2:

The reviewer noted that this is a relatively small project, but given the very limited resource constraints, the approach was sound. The interaction with companies and car makers gave it a very high credibility. The reviewer emphasized that the results were very clear and widely applicable.

Reviewer 3:

The reviewer stated that energy consumption should be examined.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer indicated that technical accomplishments have been very good. Analyses has been completed on over 21,000 vehicles showing the total calculated eVMT and vehicle average monthly eVMT and have been presented to the California Air Resources Board with respect to the zero emissions vehicle (ZEV) credit regulations.

Reviewer 2:

The reviewer stated again that the relative contributions of this project to DOE's goals given the resource constraints was very high.

Reviewer 3:
The reviewer stated that the eVMT obtained in this research help OEMs to better understand the operation characteristics of EVs and PHEVs.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer indicated that the four automotive partners in this project have provided excellent collaboration and coordination. This is a unique project because the partners actually approached INL and asked for the analysis to be performed on their data.

Reviewer 2:
The reviewer stated that the project clearly worked with a number of important organizations to collect data and understand applicability.

Reviewer 3:
The reviewer indicated that the PI has done an excellent job in collaborating with industry partners.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer stated that the proposed future work to analyze the impact of eVMT on seasonal and regional variation should provide good information. Understanding vehicle utilization when a second vehicle is used in the same household for trips greater than EV range will be a very useful analysis.

Reviewer 2:
The reviewer stated that the PI should explore the vehicle miles traveled in each trip and if the variability of charging facility in workplace will affect the vehicle miles travelled in each trip.

Question 5: Relevance - Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer stated that this project is relevant to DOE goals because the analysis results may be used by the California Air Resources Board for consideration of amendments to the Zero Emissions Vehicle credit regulations, which could provide for more benefit to using BEVs and PHEVs, which will create more petroleum displacement.

Reviewer 2:
The reviewer noted that the VMT issue is still not well understood but is a very important issue to understand the impact on DOE goals.

Reviewer 3:
The reviewer stated, yes, the application of EVs and PHEVs help to decrease the consumption of traditional gasoline and diesel fuels derived from crude oil.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer suggested that DOE add more funding to this project so that the PIs can make more efforts in evaluating the energy consumption each trip.

Reviewer 2:

The reviewer stated that resources are adequate to complete the project in a timely fashion.

Acronyms and Abbreviations

AC	Alternating Current
A/C	Air-Conditioning
ACEC	Advanced Combustion & Emissions Control
AMR	Annual Merit Review
ANL	Argonne National Laboratory
ARPA-E	Advanced Research Projects Agency - Energy
APRF	Advanced Powertrain Research Facility (ANL)
APU	Auxiliary Power Unit
ARRA	American Recovery and Reinvestment Act
AVTA	Advanced Vehicle Testing Activity
AVTE	Advanced Vehicle Testing & Evaluation
BEV	Battery Electric Vehicle
BMS	Battery Management System
BP	Budget period
BTE	Brake thermal efficiency
CAE	Computer-aided engineering
CAFE	Corporate Average Fuel Economy
CARB	California Air Resources Board
CDC	Conventional diesel combustion
CEC	California Energy Commission
CFD	Computational Fluid Dynamics
CIC	Communications, information, and communication
CLEERS	Cross-Cut Lean Exhaust Emission Reduction Simulation
CNG	Compressed Natural Gas
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CRADA	Cooperative Research and Development Agreement
CVT	Continuously variable transmission
DC	Direct Current
DCT	Dual-clutch transmission
DOD	Department of Defense
DOE	Department of Energy
DOT	Department of Transportation
DTNA	Daimler Trucks North America
ECU	Engine control unit

EDLC	Electrochemical double-layer capacitors
EG	Ethylene glycol
EGR	Exhaust Gas Recirculation
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
EREV	Extended Range Electric Vehicle
ESIF	Energy Systems Integration Facility
ESS	Energy Storage Systems
EV	Electric Vehicle
EVSE	Electric Vehicle Supplemental (Supply) Equipment
FE	Fuel economy
FHWA	Federal Highway Administration
FOA	Funding Opportunity Announcement
FTMPG	Freight ton-miles per gallon
FTP	Federal Test Procedure
FY	Fiscal Year
GDI	Gasoline direct injection
GHG	Greenhouse Gas
GREET	Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation
GSF	Generic Speed Form
GTR	Global Technical Regulation
H_2	Hydrogen
HC	Hydrocarbons
HD	Heavy-Duty
HEV	Hybrid electric vehicle
HHDDT	Heavy heavy-duty diesel truck
HHV	Hydraulic hybrid vehicle
HIL	Hardware in the Loop
HV	High voltage
HVAC	Heating, Ventilating and Air Conditioning
ICE	Internal Combustion Engine
ICNIRP	International Commission on Non-Ionizing Radiation Protection
IEC	International Electrochemical Commission
IEEE	Institute of Electrical and Electronics Engineers
IMSA	International Motor Sports Association
INL	Idaho National Laboratory

ISO	International Organization for Standardization
ITS JPO	Intelligent Transportation Systems Joint Program Office
kHz	Kilohertz
kW	Kilowatt
kWh	Kilowatt Hour
Li-ion	Lithium Ion
LD	Light-Duty
LDV	light-duty vehicle
LEESS	Lower-energy energy storage system
LIC	Lithium ion capacitor
LLNL	Lawrence Livermore National Laboratory
MBSE	Model-based system engineering
MD	Medium-Duty
MMFC	Multi-mode flow controller
MOU	Memorandum of understanding
MPG	Miles per gallon
MPGe	Miles per gallon equivalent
MPI	Message passing interface
MY	Model year
NGO	Non-governmental organization
NGV	Natural gas vehicle
NHTSA	National Highway Traffic Safety Administration
NIST	National Institute of Standards and Technology
NOx	Nitrogen Oxides
NREL	National Renewable Energy Laboratory
O_2	Oxygen
OBD	On-board diagnostics
OEM	Original Equipment Manufacturer
ORNL	Oak Ridge National Laboratory
PCM	Phase change material
PEV	Plug-in Electric Vehicle
PHEV	Plug-In Hybrid Electric Vehicle
PI	Principal Investigator
PTC	Positive temperature coefficient
QA	Quality assurance
QC	Quality control

R&D	Research and Development
RCCI	Reactivity controlled compression ignition
ROI	Return on Investment
RR	Rolling resistance
SAE	Society of Automotive Engineers
SCAQMD	South Coast Air Quality Management District
SDO	Standards definition organizations
SGIP	Smart Grid Interoperability Panel
SHA	State Highway Agency
SI	Spark Ignition
SOC	State Of Charge
SS	Steady state
TIM	Thermal interface materials
TOU	Time of use
UPS	United Parcel Service
U.S. DRIVE	U.S. Driving Research and Innovation for Vehicle efficiency and Energy sustainability
V2G	Vehicle-to-Grid
V2I	Vehicle-to-Infrastructure
V2V	Vehicle-to-Vehicle
V2X	Vehicle-to-Grid, Infrastructure, and/or Vehicle
VMT	Vehicle miles traveled
VSS	Vehicle & System Simulation
VSST	Vehicle systems safety technology
VTMS	Vehicle thermal management system
VTO	Vehicle Technologies Office
WHR	Waste Heat Recovery
WPT	Wireless Power Transfer
ZECT	Zero Emission Cargo Transport

2. Electrochemical Energy Storage

Improving the batteries for electric drive vehicles, including hybrid electric (HEV) and plug-in electric (PEV) cars, is key to improving vehicles' economic, social, and environmental sustainability. In fact, transitioning to a light-duty fleet of HEVs and PEVs could reduce U.S. foreign oil dependence by 30-60% and greenhouse gas emissions by 30-45%, depending on the exact mix of technologies. While a number of electric drive vehicles are available on the market, further improvements in batteries could make them more affordable and convenient to consumers. In addition to light-duty vehicles, some heavy-duty manufacturers are also pursuing hybridization of medium and heavy-duty vehicles to improve fuel economy and reduce idling.

The U.S. Department of Energy (DOE) Vehicle Technologies Office (VTO) focuses on reducing the cost, volume, and weight of batteries, while simultaneously improving the vehicle batteries' performance (power, energy, and durability) and ability to tolerate abuse conditions. Reaching the Office's goals in these areas and commercializing advanced energy storage technologies will allow more people to purchase and use electric drive vehicles. It will also help DOE meet the *EV Everywhere* Grand Challenge of making the United States become the first nation in the world to produce plug-in electric vehicles that are as affordable for the average American family as today's gasoline-powered vehicles within the next 10 years.

The VTO pursues three major areas of research in batteries:

- Exploratory Battery Materials Research: Addresses fundamental issues of materials and electrochemical interactions associated with lithium and beyond-lithium batteries. This research attempts to develop new and promising materials, use advanced material models to predict the modes in which batteries fail, and employ scientific diagnostic tools and techniques to gain insight into why materials and systems fail. Building on these findings, it works to develop ways to mitigate those failures.

- Applied Battery Research: Focuses on optimizing next generation, high-energy lithium ion electrochemistries that incorporate new battery materials. The activity emphasizes identifying, diagnosing, and mitigating issues that negatively impact the performance and life of cells using advanced materials.

- Advanced Battery Development, System Analysis, and Testing: Focuses on the development of robust battery cells and modules to significantly reduce battery cost, increase life, and improve performance. This research aims to ensure these systems meet specific goals for particular vehicle applications.

This research builds upon decades of work that DOE has conducted in batteries and energy storage. Research supported by VTO led to today's modern nickel metal hydride batteries, which nearly all first generation hybrid electric vehicles used. Similarly, the Office's research also helped develop the lithium-ion battery technology used in the Chevrolet Volt, the first commercially available plug-in hybrid electric vehicle. This technology is now being used in a variety of hybrid and plug-in electric vehicles coming on the market now and in the next few years, including the Ford Focus EV.

As described in the *EV Everywhere* Blueprint, the major goals of the Batteries and Energy Storage subprogram are by 2022 to:

- Reduce the production cost of an electric vehicle battery to a quarter of its current cost;

- Halve the size of an electric vehicle battery; and

- Halve the weight of an electric vehicle battery;

Achieving these goals would result in:

- Lowering battery cost from $500/kwh to $125/kwh; and
- Increasing energy and power densities from 100 Wh/kg to 250 Wh/kg, 200 Wh/l to 400 Wh/l, and 400 W/kg to 2000 W/kg.

Subprogram Feedback

DOE received feedback on the overall technical subprogram areas presented during the 2015 Annual Merit Review (AMR). Each subprogram technical session was introduced with a presentation that provided an overview of subprogram goals and recent progress, followed by a series of detailed topic area project presentations.

The reviewers for a given subprogram area responded to a series of specific questions regarding the breadth, depth, and appropriateness of that DOE VTO subprogram's activities. The subprogram overview questions are listed below, and it should be noted that no scoring metrics were applied. These questions were used for all VTO subprogram overviews.

Question 1. Was the program area, including overall strategy, adequately covered?

Question 2. Is there an appropriate balance between near- mid- and long-term research and development?

Question 3. Were important issues and challenges identified?

Question 4. Are plans identified for addressing issues and challenges?

Question 5. Was progress clearly benchmarked against the previous year?

Question 6. Are the projects in this technology area addressing the broad problems and barriers that the Vehicle Technologies Office (VTO) is trying to solve?

Question 7. Does the program area appear to be focused, well-managed, and effective in addressing VTO's needs?

Question 8. What are the key strengths and weaknesses of the projects in this program area? Do any of the projects stand out on either end of the spectrum?

Question 9. Do these projects represent novel and/or innovative ways to approach these barriers as appropriate?

Question 10. Has the program area engaged appropriate partners?

Question 11. Is the program area collaborating with them effectively?

Question 12. Are there any gaps in the portfolio for this technology area?

Question 13. Are there topics that are not being adequately addressed?

Question 14. Are there other areas that this program area should consider funding to meet overall programmatic goals?

Question 15. Can you recommend new ways to approach the barriers addressed by this program area?

Question 16. Are there any other suggestions to improve the effectiveness of this program area?

Responses to the subprogram overview questions are summarized in the following pages. Individual reviewer comments for each question are identified under the heading Reviewer 1, Reviewer 2, etc. Note that reviewer comments may be ordered differently; for example, for each specific subprogram overview presentation, the reviewer identified as Reviewer 1 in the first question may not be Reviewer 1 in the second question, etc.

Subprogram Overview Comments: Peter Faguy (U.S. Department of Energy) – es000

Question 1: Was the program area, including overall strategy, adequately covered?

Reviewer 1:

The reviewer said yes, and that the strategy was covered very well from an automotive original equipment manufacturer (OEM) perspective.

Reviewer 2:

The reviewer remarked that the overview was necessarily brief. The presentation culled out some highlights of what was accomplished and mentioned the goals. The reviewer suggested that more information on why certain areas are being included and excluded would have been helpful. The reviewer believed that successful implementation of electric vehicles is being held up by the difficult material challenges faced. The reviewer believed that a lot of the manufacturing, cost modeling, and even the pack control systems can come along later. Consequently, the 22% of the funding pie for exploratory materials research seems far too low, but the reviewer believed that materials research makes up a large portion of the DOE Funding Opportunity Announcements (38%). If that is indeed the case, then the reviewer approves of the funding split, otherwise the reviewer suggests boosting the materials portion of the pie.

Reviewer 3:

The reviewer found that a general ongoing strategy can be deduced from the projects underway, the projects completed, and future plans. However, there was no overall strategy described that illustrates any particular direction for the future.

Question 2: Is there an appropriate balance between near- mid- and long-term research and development?

Reviewer 1:

The reviewer pointed out that the automotive industry has a long lead time for implementation of new technology. The time frames provided establish time periods that appear to fit the near-, mid-, and mid-long term research development schedules.

Reviewer 2:

The reviewer was impressed with the wide range of the programs being funded within the near- and mid-term implementation timeline (5-15 years). The reviewer agreed with leaving much longer-term prospects for vehicle applications, such as magnesium and lithium-air batteries, to other programs, such as Advanced Research Projects Agency - Energy (ARPA-E) and Joint Center for Energy Storage Research (JCESR) that can better accommodate the much higher risks associated with such systems. The program is focused on an array of anodes and cathodes, but costing and energy/power requirements are being used to direct the work so that it is not wasted on systems/materials that have no hope of meeting the targets. The reviewer believed that in almost all areas, if the projects were to be successful, they would be very impactful (i.e., “if you had, you would indeed want it”). Thus, the reviewer thinks that the program managers have used a very disciplined approach to select projects with varying degrees of risk that are yet generally aligned with the program goals. The reviewer pointed out that some of the method development in this program is outstanding and should provide valuable tools to really understand what is going on in these systems for many years to come.

Reviewer 3:

The reviewer suggested greater focus on near-term research & development (R&D) and manufacturing issues, and more advanced fundamental science, rather than on mid-term R&D can better position the United States in this industry.

Question 3: Were important issues and challenges identified?

Reviewer 1:
The reviewer said yes, and explained that frankly, everyone knows the challenges and issues.

Reviewer 2:
The reviewer found that most of the key high-voltage battery issues were identified, such as the need for the key cell components (cathode and electrolyte in particular) to have high voltage capability; the need for improvement in the anode to obtain higher energy density by using silicon; and improvement in manufacturing/processes to reduce overall cell/system cost.

Reviewer 3:
The reviewer said that issues and challenges were identified at a high level.

Question 4: Are plans identified for addressing issues and challenges?

Reviewer 1:
The reviewer said yes, the plans were identified to address the issues and challenges. This was done by offering various funding opportunities; identifying multiple paths that offer potential solutions; and, finally providing the appropriate funding method to help respondents prove out their proposed solution.

Reviewer 2:
The reviewer said that plans were identified at a high level.

Reviewer 3:
The reviewer thinks that the goals are clear and the presentation touches on some of the highlights, but there was little in there on details of the overall plan. The reviewer was happy with the portfolio of projects being undertaken, and presumably this is a reflection of DOE's planning in this area, but the plans were not explicitly discussed in any depth, at least not that the reviewer can recall. The reviewer presumed plans are laid out in detail in some of the extremely large documents on VTO's website, but there really was no time to get into this during the time allotted for the presentation.

Question 5: Was progress clearly benchmarked against the previous year?

Reviewer 1:
The reviewer found that the progress while not clearly benchmarked against the previous year were sufficiently identified. The reviewer pointed out that the addition of the U.S. Advanced Battery Consortium (USABC) programs was added, new testing efforts were added, and the computer-aided engineering of batteries (CAEBAT) efforts were added.

Reviewer 2:
The reviewer said yes, but at a very general and very high level. The reviewer thought the level was too high and too general.

Reviewer 3:
The reviewer said not really, although progress versus the goals was fairly clear. In terms of progress since last year, the reviewer said that cost estimates of packs are much more developed, as is the modeling of battery pack performance under CAEBAT. There was also some very interesting method development going on. The reviewer pointed out that some of the advances in getting silicon to cycle look promising, but translating this into commercial cells seems to be a major hurdle that remains elusive. The reviewer did not believe that the cathode work or electrolyte work showed major advances, although the reviewer thought some of the projects look very promising so maybe next year they will bear fruit.

Question 6: Are the projects in this technology area addressing the broad problems and barriers that the Vehicle Technologies Office (VTO) is trying to solve?

Reviewer 1:

The reviewer noted that the projects that have been selected are addressing the issues that were identified earlier.

Reviewer 2:

The reviewer said yes.

Reviewer 3:

The reviewer said yes, and elaborated that in almost every case the reviewer understood the point of why the project was funded.

Question 7: Does the program area appear to be focused, well-managed, and effective in addressing VTO's needs?

Reviewer 1:

The reviewer emphatically said yes.

Reviewer 2:

The reviewer found that the focus could be much greater and could be significantly improved, but it is effective in addressing VTO's needs

Reviewer 3:

The reviewer believed that the projects are in general worthwhile and targeted at the main problems. The reviewer cautioned that despite the following criticisms, overall the reviewer thought the program team is doing a very good job in managing the project portfolio.

Notwithstanding the above, the reviewer believed that some of the costing work is overkill. The reviewer noted that the models of plant costs seemed acceptable, but some of the items DOE was looking at were pretty unimportant (cutting maybe $25 from a car battery pack). The reviewer suggested that perhaps the outcome is unknown until models are run, but the reviewer thinks this could really be left to industry, which obsesses about running efficient plants 24/7. The reviewer said that most of the costs still seem to be in raw materials, and asked if energy costs are really that important.

The reviewer cited modeling work as the biggest problem. The reviewer noted that the program includes a wide array of modeling, all the way from ab initio modeling of atoms to thermal/electrical modeling of complete battery packs. Taken individually, the reviewer had no issue with the various projects being taken. However, the reviewer believed that the efforts remain far too uncoordinated. Basic problems the reviewer cited are that: there does not seem to be a master plan of the desired future state of the modeling activities; modelers seem to be doing what they can or want to do, not what needs to be done; and communication among the modelers seems poor, especially among different programs within the DOE. The reviewer applauded the CAEBAT effort to rein in these disparate modeling initiatives, this is really making the best of a bad situation. The reviewer believes that fundamentally, the issues are mainly a result of the proposal-driven funding mechanism used by DOE (and many other government agencies). While this mechanism has of course some merits, the reviewer believed it has led to many uncoordinated and in some cases competing efforts.

Ideally, the reviewer would like to see a comprehensive evaluation and outlining of what exactly the program actually needs in the various modeling areas and then assignments made to the groups best positioned to address those needs. The reviewer does not believe that the request for proposals really do this in any truly coordinated way. The reviewer appreciates that such an approach may not be viable for a government run program, but the modeling efforts badly need more oversight and control. The reviewer suggested maybe having a modeling czar selected from one of the experienced modelers in the middle of the micro-meso-macro scale of models to help create such a plan, and suggested maybe Dennis Dees.

If, as is likely, such an approach cannot be taken, the reviewer suggested continuing to support the CAEBAT program that at least tries to make sure the programs standardize on the language, etc. Regardless of the above strategy, the reviewer believed that there should much more frequent communications among the modelers at all levels and across all programs. While there is of course a big difference between the type of modeling at the ab initio versus pack level, the reviewer believed that more frequent working meetings to share what modelers are doing would be very beneficial. The reviewer pointed out that some of the modelers do not seem to know what others are doing until they come to the Annual Merit Review (AMR).

Question 8: What are the key strengths and weaknesses of the projects in this program area? Do any of the projects stand out on either end of the spectrum?

Reviewer 1:

The reviewer identified as a key weakness the lack of responders to the proposals that have a strong chance of meeting the proposal requirements. The reviewer is unsure if this is because of the requirements in the Funding Opportunity Announcements (FOAs)/request for proposal information (RFPIs) or something else. The reviewer said that the strengths are the variety of opportunities that are offered and the quick response when new technology needs are identified. This variety in funding and quick response is evident in the USABC project/program as other opportunities were opened to allow for additional responses. The reviewer detailed that this was done by developing new RFPIs in concert with DOE, without much overlapping with DOE's existing FOAs.

Reviewer 2:

The reviewer pointed out that battery manufacturing initiatives, Battery Materials Research, and USABC stand out as the most useful aspects.

Reviewer 3:

The reviewer thinks the strengths of many of the programs are their originality and focus on the main issues at hand. The reviewer thought that the following projects were excellent. Mike Thackeray’s talk (es049) was very promising, and the reviewer believed that while the lithium-manganese rich (LMR) material might never be able to deliver its original potential capacity while retaining the cycle life needed for vehicle applications, taking a small cut in capacity to attain the stability needed would nevertheless be a huge step forward.

The reviewer supported Stanley Whittingham’s work on alternate anodes that are less reactive than lithiated silicon. The reviewer remains very concerned that after more than a decade of extensive work, silicon (Si) anodes are only being used in very small amounts in consumer applications (LG and Samsung) where cycle life demands are far less rigorous. The reviewer pointed out that despite all the work showing good cycle life of Si anodes, getting stable performance in a full cell still seems to be very challenging. The reviewer thought that Clare Grey’s nuclear magnetic resonance (NMR) work and method development seemed truly groundbreaking. The reviewer cited various projects to extend in situ diagnostic methods to run in operando. The reviewer thought that Andrew Jansens’s poster (es030) on the Cell Analysis, Modeling, and Prototyping (CAMP) lab at Argonne National Laboratory (ANL) showed that the team has been extremely productive and are providing a valuable service to the community. More importantly, the reviewer thought that the team appears to be involved in planning the work. This is a crucial involvement to both ensure relevance of the work and good data interpretation.

The reviewer was impressed by Dean Wheeler and Brian Mazzeo’s work (es220). The reviewer found that the method he and his partner have devised to map the electronic conductivity of an electrode is very important to the industry. Uneven current distributions in cells from non-uniform electrodes can reduce cycle life and/or lead to lithium plating. The reviewer provided as an example, at the spring 2015 ECS meeting a few weeks ago, Tobias Bach showed how the pressure from just the tab of a cell can lead to non-uniform discharge currents that then greatly reduce cycle life. Stephen Harris and others have also highlighted the importance of having uniform electrodes. Developing their method to also map ionic conductivity would also be an invaluable extension of this method. The reviewer pointed out the ab initio modeling work at Lawrence Berkeley National Laboratory (LBNL) and Massachusetts Institute of Technology (MIT). The reviewer thought that what was great was the project team can explain their results and especially provide insight that cannot often be achieved from experiments – not just results. The reviewer thought that Kevin Gallagher's paper presented by Dennis Dees also provided valuable insight.

The reviewer pointed out various initiatives looking at lower cost and/or radically different ways to make electrodes. About new electrodes, the reviewer said that this is a difficult area where little has really changed over the last 20 years or so, but the reviewer credited VTO for putting together a surprisingly good selection of projects that are really very innovative. The reviewer said that the use of ionic liquids as an electrolyte for lithium-oxygen by Vincent Giordani (LIOX, es233) was interesting, as long as the energy losses to keep the pack warm would be acceptable.

The reviewer thought there were somewhat weak areas. According to the reviewer, the car battery market will not really take off until battery costs come down. Because raw materials costs still dominate, this means less expensive raw materials and this in turn is likely to make it uneconomic to recycle these batteries for their components. However, undesirable it would be from an environmental or resource issue, it may well end up being cheaper to just dig up more stuff from the ground than to recycle. The reviewer suggested that DOE should be focused on developing policies to address this, although maybe this is not VTO's role. The reviewer believed that most Western countries will simply mandate recycling and thus the costs for this will actually have to be added in to the production in costs for the battery because the reviewer does not believe recycling these batteries may ever be profitable. Another option that the reviewer presumes will not come to pass even in the United States, is not requiring recycling, but leave the landfilling open as an option, but the reviewer noted that again this cost should be including in the battery costs.

The reviewer identified modeling of plant costs, and elaborated that models seemed acceptable, but some of the items examined were pretty unimportant, such as cutting maybe $25 from a car battery pack. The reviewer suggested that perhaps the outcome is unknown until models are run, but the reviewer thinks this could really be left to industry, which obsesses about running efficient plants 24 hours a day, 7 days a week. Most of the costs still seem to be in raw materials. The reviewer said that the work at Argonne to find a new organic solvent (es066) did not seem to be coming up with anything new. The reviewer pointed out es215 and suggested that, being new to the field, this principal investigator (PI) would benefit from a much closer working relationship with existing partners at Berkeley.

Question 9: Do these projects represent novel and/or innovative ways to approach these barriers as appropriate?

Reviewer 1:

The reviewer said yes, these projects do represent novel ways. The reviewer said that the goals in the FOAs and the RFPIs are sufficiently aggressive to drive the need to develop novel/innovative solutions to meet the target.

Reviewer 2:

The reviewer said that some projects do.

Reviewer 3:

The reviewer would generally characterize the approaches as quite innovation and a credit to DOE's program. The reviewer believed that not enough attention is given to some of the drawbacks of the nano-approaches so prevalent in terms of poor packing; high surface area and the reactivity associated with that; energy and power on a volume as well as weight basis; electrolyte needed to wet all the surfaces; and costs

Question 10: Has the program area engaged appropriate partners?

Reviewer 1:
The reviewer said that the program has an excellent group of partners. The reviewer cited automotive original equipment manufacturers (OEMs), battery manufacturers, and battery component suppliers are included and address the near- and mid-term needs; while universities, national laboratories, and research companies cover in particular the long-term research concerns.

Reviewer 2:
The reviewer said that as restricted by DOE's governmental restrictions, yes. However, according to the reviewer the entire program could much better position the United States and U.S. industries if greater allowance and initiative for international partnership and collaboration was enacted.

Reviewer 3:
The reviewer said yes, and elaborated that VTO has a wide range of industrial partners in both materials, processing and pack assembly. The reviewer wished that LG and Samsung or some Japanese companies were more involved because they can bring a lot of realism to the party, but the reviewer understands that this is not very attractive in terms of developing a U.S.-based supply chain. The reviewer noted that these companies may not be willing to contribute much due to the competitive nature of their business. The reviewer said that the national laboratories and universities are all pulling their weight and contributing to the program.

Question 11: Is the program area collaborating with them effectively?

Reviewer 1:
The reviewer said yes, the program is collaborating very well with all of the partners.

Reviewer 2:
The reviewer was amazed at the sheer number of collaborators listed on some posters and talks. The reviewer suspected that this is in part due to the prominence this is given in the reviewing form. The reviewer noted that collaboration requires some investment in time and money, so the reviewer could see that in some cases maybe project teams actually have too many. The reviewer does not believe that collaboration should be an end of itself.

The reviewer pointed out that the big question is how effective are the collaborations and it is very hard to tell that from the presentations. A promising indicator was that several PIs told this reviewer the project teams have regular meetings with the stakeholders and other researchers to discuss progress, which the reviewer thinks is great, especially if meetings can be kept informal and focused on technical not managerial aspects. Others conveyed to this reviewer that project teams received valuable guidance from their partners.

Based on this, the reviewer believes that the collaboration is actually working out very well. The reviewer noted es215, and that with this PI being new to the field, this PI would benefit from a much closer working relationship with existing partners at Berkeley. The reviewer expressed concern that this PI seemed far too unaware of what the field is doing and trying to do.

Question 12: Are there any gaps in the portfolio for this technology area?

Reviewer 1:
The reviewer said that there are no obvious gaps in the key technology areas.

Reviewer 2:
The reviewer understands the Bollore Li-vanadium oxide battery systems are being used in France, and asked if DOE is talking with these folks. Stability of a protected lithium anode to physical abuse and consequences of the film rupture during such events. The reviewer would like to know how well these films are likely to stand up to a crash scenario.

Question 13: Are there topics that are not being adequately addressed?

Reviewer 1:
The reviewer said that there is no clear lack of depth in the work for any of the identified topics.

Reviewer 2:
The reviewer cited electrolytes, separators, and advanced anodes with more and international partners

Reviewer 3:
The reviewer would like to see a better understanding of why exactly the advanced silicon anodes are not making into commercial cells, especially those for consumer devices where 300-500 cycles is often adequate. The reviewer would like to know if the barrier is the physical expansion and/or chemical side reactions. The reviewer pointed out that assumptions made of lithium metal cells depend very much on the efficiency used and the amount of excess lithium that is then required. The reviewer asked how this is factored into energy density/specific energy estimates. The reviewer recommended that Vince Battaglia (es232) should run a test of cell reproducibility either by making and testing a large batch of control cells (say 10) or better by including 2 control cells in each of the experiments and over time building up a database. The reviewer believed this would capture run-to-run as well as within-a-run variability. The reviewer stipulated that maybe the PI already has this, but the PI said not.

Question 14: Are there other areas that this program area should consider funding to meet overall programmatic goals?

Reviewer 1:
The reviewer said yes, and cited relationship and partnering of consumer electronics manufacturers and cell manufacturers with automotive and automotive-related participants.

Reviewer 2:
The reviewer said that fast charging has received some attention; however, one area that may need to be addressed is the quick removal of stranded energy from batteries that may have been involved in an accident. This area is in particular to address safety concerns, but may drive technology improvements in many areas or/and drive design commonality in some areas. The reviewer suggested that the effect that fast charging has on battery safety and battery life should be considered for future work.

Reviewer 3:
The reviewer suggested creating an overall master plan for the various modeling initiatives

Question 15: Can you recommend new ways to approach the barriers addressed by this program area?

Reviewer 1:
The reviewer cannot think of any new ways to approach these barriers.

Reviewer 2:
The reviewer suggested increasing relative funding to allow for continued funding of national laboratories at similar levels while increasing relative funding to industrial partners in the United States and internationally.

Reviewer 3:
The reviewer thought Wildcat Technologies' high throughput methodology is tailor made to looking at electrolyte and other additives. The reviewer strongly encouraged that this organization be tasked to take a look as this. In the reviewer's view, this entity has a very good track record.

Question 16: Are there any other suggestions to improve the effectiveness of this program area?

Reviewer 1:

The reviewer cannot think of any at this time.

Reviewer 2:

The reviewer noted that there seems to be some issues with the basic understanding of ANL's LMR cathode between Berkeley and other labs regarding the presence of microdomains of $LiMn_2O_3$. The reviewer noted that while disagreements are fine, the reviewer believed that the groups are talking past each other via publications and not directly with each other. The reviewer believed the program managers should try and force the issue to see whether a consensus can be reached, i.e., identify who's right. The reviewer acknowledged that sometimes there is not enough information to take this approach, but the reviewer believed that with all the studies being done on this material, there should be enough information to come to a resolution.

The reviewer expressed concern that Nancy Dudney's work (es182) seems to have progressed a bit slowly. The reviewer thinks this is important and that the PI may need an extension to complete the work properly. The reviewer fears there is still far too much to do before the funding runs out. The reviewer said that those developing new methods seem to be rushed to apply them to lots of materials right away, presumably to show relevance and highlight the importance of the work. The reviewer fears the project teams are rushing into the application field too quickly, before the teams have really done a thorough job of validating the method. The reviewer was happy to see that Clare Grey's group took a time-out to look at their methods in such detail.

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.

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Novel Cathode Materials and Processing Methods	Thackeray, Michael (ANL)	2-22	3.50	3.67	3.83	3.67	3.65
High-Capacity, High-Voltage Cathode Materials for Lithium-Ion Batteries	Manthiram, Arumugam (U of Texas at Austin)	2-25	3.00	3.00	2.67	2.83	2.94
Design of High-Performance, High-Energy Cathode Materials	Doeff, Marca (LBNL)	2-28	3.17	3.50	3.67	3.17	3.40
First Principles Calculations of Existing and Novel Electrode Materials	Ceder, Gerbrand (Massachusetts Institute of Technology)	2-31	3.83	3.67	3.67	3.50	3.69
First Principles Calculations and NMR Spectroscopy of Electrode Materials	Grey, Clare (U. of Cambridge)	2-34	3.50	3.33	3.50	3.17	3.38
Development of High-Energy Cathode Materials	Zhang, Jason (PNNL)	2-37	3.00	3.17	3.50	2.67	3.10
Advanced In-Situ Diagnostic Techniques for Battery Materials	Yang, Xiao-Qing (BNL)	2-41	3.00	3.17	3.33	3.00	3.13

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Development of Novel Electrolytes and Catalysts for Lithium-Air Batteries	Amine, Khalil (ANL)	2-44	3.67	3.50	3.67	3.67	3.58
Design and Scalable Assembly of High-Density Low-Tortuosity Electrodes	Chiang, Yet-Ming (Massachusetts Institute of Technology)	2-47	3.13	3.38	3.13	3.25	3.27
Interfacial Processes in EES Systems Advanced Diagnostics	Kostecki, Robert (LBNL)	2-50	3.67	3.83	3.50	3.67	3.73
Predicting and Understanding Novel Electrode Materials From First Principles	Persson, Kristin (LBNL)	2-53	3.67	3.67	3.67	3.50	3.65
Studies on High Capacity Cathodes for Advanced Lithium-Ion Systems	Nanda, Jagjit (ORNL)	2-56	3.00	3.33	3.67	3.00	3.25
PHEV and EV Battery Performance and Cost Assessment	Gallagher, Kevin (ANL)	2-59	3.50	3.70	3.20	3.40	3.55
Open Architecture Software for CAEBAT	Turner, John (ORNL)	2-62	3.00	3.00	2.83	2.83	2.96
Composite Electrolytes to Stabilize Metallic Lithium Anodes	Dudney, Nancy (ORNL)	2-65	2.75	2.75	3.00	2.75	2.78

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
In-Situ Solvothermal Synthesis of Novel High Capacity Cathodes	Wang, Feng (BNL)	2-68	3.00	3.00	3.67	2.83	3.06
Lithium Bearing Mixed Polyanion Glasses as Cathode Materials	Kercher, Andrew (ORNL)	2-71	3.00	2.83	3.17	2.83	2.92
Significant Enhancement of Computational Efficiency in Nonlinear Multiscale Battery Model for Computer Aided Engineering †	Kim, Gi-Heon (NREL)	2-74	3.67	3.67	3.17	3.17	3.54
Mechanistic Modeling Framework for Predicting Extreme Battery Response: Coupled Hierarchical Models for Thermal, Mechanical, Electrical and (Electro)Chemical Processes †	Moffat, Harry (SNL)	2-77	3.83	3.33	3.50	3.17	3.46
Coupling Mechanical with Electrochemical-Thermal Models Batteries under Abuse †	Pesaran, Ahmad (NREL)	2-80	3.83	3.33	3.33	3.50	3.48

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Efficient Safety and Degradation Modeling of Automotive Lithium-Ion Cells and Pack †	Shaffer, Christian (EC-Power)	2-83	3.00	3.00	3.00	2.67	2.96
Electrochemical Performance Testing †	Bloom, Ira (ANL)	2-86	3.50	3.50	3.75	3.50	3.53
INL Electrochemical Performance Testing †	Christophersen, Jon (INL)	2-88	3.75	3.75	4.00	4.00	3.81
Battery Safety Testing †	Orendorff, Christopher (SNL)	2-90	4.00	3.75	4.00	4.00	3.88
Battery Thermal Characterization †	Keyser, Matthew (NREL)	2-92	3.25	3.50	3.25	3.50	3.41
New High-Energy Electrochemical Couple for Automotive Applications †	Amine, Khalil (ANL)	2-94	3.38	3.50	3.38	3.50	3.45
High-Energy High-Power Battery Exceeding PHEV-40 Requirements †	Rempel, Jane (TIAX)	2-98	3.00	2.88	2.75	2.50	2.84
Advanced High-Energy Lithium-Ion Cell for PHEV and EV Applications †	Singh, Jagat (3M)	2-102	3.13	3.13	3.38	3.13	3.16
High-Energy Lithium Batteries for PHEV Applications †	Venkatachala, Subramanian (Envia)	2-105	3.38	3.38	3.38	3.25	3.36

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
High-Energy, Long Cycle Life Lithium-Ion Batteries for PHEV Applications †	Wang, Donghai (Penn State)	2-108	3.00	3.00	3.00	3.00	3.00
High Energy Density Lithium-Ion Cells for EV's Based on Novel, High Voltage Cathode Material Systems †	Kepler, Keith (Farasis)	2-112	3.50	3.50	3.50	3.38	3.48
First Principles Modeling of SEI Formation on Bare and Surface/Additive Modified Silicon Anodes	Balbuena, Perla (Texas A&M)	2-115	3.17	3.17	3.00	2.83	3.10
Analysis of Film Formation Chemistry on Silicon Anodes by Advanced In Situ and Operando Vibrational Spectroscopy	Somorjai, G. (UC Berkeley)	2-118	3.17	3.00	2.50	3.17	3.00
Optimization of Ion Transport in High-Energy Composite Cathodes	Meng, Shirley (UC San Diego)	2-121	3.50	3.25	3.75	3.50	3.41
Daikin Advanced Lithium-Ion Battery Technology - High-Voltage Electrolyte	Hendershot, Ron (Daikin America)	2-125	3.50	3.67	2.67	3.33	3.46
Fluorinated Electrolyte for 5 V Lithium-Ion Chemistry	Zhang, John (ANL)	2-128	3.33	3.00	3.00	2.83	3.06

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Novel Non-Carbonate Based Electrolytes for Silicon Anodes	Strand, Dee (Wildcat Discovery)	2-131	3.17	3.33	3.50	3.00	3.27
Predicting Microstructure and Performance for Optimal Cell Fabrication	Wheeler, Dean (BYU)	2-134	3.38	3.25	3.25	3.13	3.27
A Combined Experimental and Modeling Approach for the Design of High Coulombic Efficiency Si Electrodes	Xiao, Xingcheng (GM)	2-137	3.33	3.17	3.33	2.83	3.19
Electrode Architecture-Assembly of Battery Materials and Electrodes	Zaghib, Karim (Hydro Quebec)	2-140	3.25	3.38	3.38	3.13	3.31
Hierarchical Assembly of Inorganic/Organic Hybrid Si Negative Electrodes	Liu, Gao (LBNL)	2-143	3.88	3.75	3.75	3.38	3.73
Simulations and X-ray Spectroscopy of Lithium-Sulfur Chemistry	Balsara, Nitash (LBNL)	2-146	3.25	3.00	3.13	2.88	3.06
Design and Synthesis of Advanced High-Energy Cathode Materials	Chen, Guoying (LBNL)	2-149	3.33	3.50	3.50	3.33	3.44

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Microscopy Investigation on the Fading Mechanism of Electrode Materials	Wang, Chongmin (PNNL)	2-152	3.88	3.88	3.88	3.50	3.83
BatPaC Model Development	Ahmed, Shabbir (ANL)	2-155	3.50	3.67	3.33	3.42	3.55
Lithium-Ion Battery Production and Recycling Materials Issues	Gaines, Linda (ANL)	2-159	3.50	3.42	2.83	2.92	3.30
Sulfur Cathode for Lithium Sulfur Batteries	Cui, Yi (Stanford University)	2-163	3.25	3.25	3.13	3.13	3.22
High Energy Density Lithium Battery	Whittingham, Stanley (Binghamton U.-SUNY)	2-166	3.50	3.13	3.00	3.13	3.20
Electrode Fabrication and Performance Benchmarking	Battaglia, Vincent (LBNL)	2-169	3.00	3.50	3.38	3.13	3.31
Efficient Rechargeable Li/O_2 Batteries Utilizing Stable Inorganic Molten Salt Electrolytes	Giordani, Vincent (Liox)	2-172	3.50	3.17	3.33	3.33	3.29
Continuum Modeling as a Guide to Developing New Battery Materials	Srinivasan, Venkat (LBNL)	2-175	3.50	3.33	3.17	3.50	3.38
Energy Storage Materials Research Using DOE's User Facilities	Thackeray, Michael (ANL)	2-177	3.17	3.00	3.17	2.83	3.04

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Crash Propagation Simulations and Validation †	Santhanagopalan, Shriram (NREL)	2-180	3.25	3.50	3.25	3.25	3.38
XG Sciences: Development of Silicon Graphene Composite Anode †	Privette, Robert (XG Sciences)	2-182	3.50	3.33	3.67	3.50	3.44
Low-Cost, High-Capacity Lithium-Ion Batteries through Modified Surface and Microstructure †	Zhang, Pu (Navitas Systems)	2-184	3.17	2.83	2.00	3.00	2.83
Scale-Up of Low-Cost Encapsulation Technologies for High-Capacity and High-Voltage Electrode Powders †	King, David (Pneumaticoat Technologies)	2-186	3.67	3.50	2.50	3.33	3.40
Development of Silicon Graphene Composite Anode †	Mayekar, Samir (Sinode Systems)	2-188	3.50	3.33	3.50	3.17	3.38
A Disruptive Concept for a Whole Family of New Battery Systems †	Roumi, Farshid (Parthian Energy)	2-190	2.33	1.67	1.00	2.00	1.79

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Dramatically Improve the Safety Performance of Lithium-Ion Battery Separators and Reduce the Manufacturing Cost using Ultraviolet Curing and High Precision Coating Technologies †	Arnold, John (Miltec UV International)	2-192	2.83	2.33	2.00	1.83	2.35
Low-Cost, High-Capacity Non-Intercalation Chemistry Automotive Cells †	Jacobs, Alex (Sila Nanotechnologies)	2-195	3.00	3.13	2.50	2.50	2.94
Low-Cost, Structurally Advanced Novel Electrode and Cell Manufacturing †	Tan, Taison (24M Technologies)	2-198	2.17	2.17	2.00	2.33	2.17
Advanced Drying Process for Lower Manufacturing Cost of Electrodes †	Ahmad, Iftikhar (Lambda Technologies)	2-200	3.13	3.13	3.00	2.63	3.05
EV Battery Development †	Lopez, Herman (Envia Systems)	2-203	3.50	3.50	3.50	3.00	3.44
Development of a PHEV Battery †	Busbee, John (Xerion Advanced Battery Corporation)	2-206	2.33	2.17	2.50	2.33	2.27
Battery Development †	Alamgir, Mohamed (LG Chem Power)	2-209	3.17	2.83	2.83	3.17	2.96
A Commercially Scalable Process for Silicon Anode Prelithiation †	Stefan, Ionel (Amprius)	2-212	3.50	2.83	3.17	3.33	3.10

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
12 V SS Battery Development †	Everett, Michael (Maxwell)	2-215	3.17	2.67	2.83	3.00	2.85
New High-Energy Electrochemical Couple for Automotive Application †	Yang, Xiao-Qing (BNL)	2-218	3.63	3.63	3.50	3.50	3.59
3M IC3P - Research Focus †	Singh, Jagat (3M)	2-221	3.13	3.00	2.75	2.63	2.95
Ion-Exchanged Derived Cathodes (IE-LL_NCM) for High-Energy Density Lithium-Ion Batteries †	Johnson, Christopher (ANL)	2-224	3.50	3.13	3.00	3.00	3.19
Envia IC3P - Research Focus †	Kostecki, Robert (LBNL)	2-227	3.38	3.50	3.38	2.88	3.38
Prospects and Challenges of Nickel-Rich Layered Oxide Cathodes †	Manthiram, Arumugam (U of Texas at Austin)	2-230	3.50	3.25	3.00	3.13	3.27
Materials Development for High Energy High Power Battery Exceeding PHEV-40 Requirements †	Rempel, Jane (TIAX)	2-233	3.00	3.00	2.63	3.00	2.95
Overall Average			**3.30**	**3.23**	**3.17**	**3.11**	**3.23**

Note: † denotes poster presentation.

Novel Cathode Materials and Processing Methods: Michael Thackeray (Argonne National Laboratory) - es049

Presenter

Michael Thackeray, Argonne National Laboratory.

Reviewer Sample Size

A total of three reviewers evaluated this project.

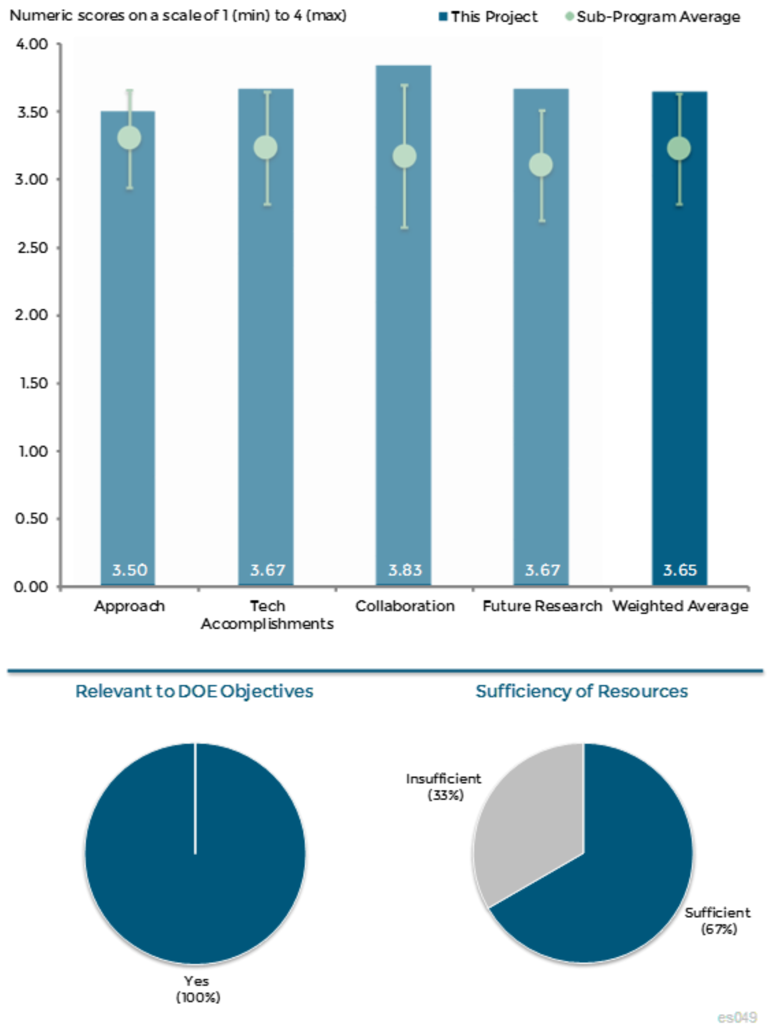


Figure 2-1 Novel Cathode Materials and Processing Methods: Michael Thackeray (Argonne National Laboratory) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This is good fundamental research to understand the phase transition mechanisms, in the opinion of this reviewer.

Reviewer 2:

Although the concept of tailoring the bulk structure is very sound, and in fact may be the only option, and although early results show some promise with regard to reduction in voltage fade, jury is still out, the reviewer said, on the overall efficacy of this stabilization approach. There is currently no data, the reviewer continued, on oxygen evolution, manganese (Mn) dissolution and corresponding life data, all of which are significant drawbacks of the layered lithium (LL) materials. Thus, the reviewer concluded that it is too early to comment on how effective this approach will be.

Reviewer 3:

The objective here, the reviewer said, is to develop structurally integrated cathode structures, layered-layered-spinel, to overcome the issues inherent in layered-layered composite cathodes, especially voltage fade. The approach is to embed a spinel component of six to 15% into the layered-layered structure, and further stabilize the electrode with a suitable surface coating, the reviewer went on, adding that the latter approach is not as novel. Considering the problems encountered with layered-layered composite electrodes, this approach may provide a viable pathway, in the reviewer’s opinion. However, the reviewer noted, there is considerable reduction both in the cell capacity (approximately 200 mAh/g) and energy (low discharge voltage), so these materials may not compete well with simple, surface-treated, nickel (Ni)-rich layered cathodes operating at these voltages, especially with comparable electrode loadings. The expectation is that thermal stability will be better with the current materials, according to the reviewer, but a proper comparison is required to better understand the benefits here. On the other hand, the reviewer noted, these studies provide an excellent platform to understand Mn-based composite cathodes.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

Early results are excellent compared to previous data, the reviewer said, but many key data are needed to make an overall judgement are still missing, so excitement would be premature. Information the reviewer regards as missing includes high-temperature performance, especially life, power over state of charge (SOC) and Mn dissolution, among others. Missing also, according to the reviewer, are data on the surface properties of the TM of these new materials. Finally, the reviewer wondered if there is any difference in the oxidation state of the surface TM of this material versus the baseline materials.

Reviewer 2:

Excellent progress has been made in designing the layered-layered cathodes with embedded spinel component, the reviewer observed, and with such an embedded spinel component (of 6%), and with low cobalt (Co) content, good cyclic stability was demonstrated without the onset of voltage fade, albeit with a lower charge voltage. It appeared to the reviewer to be more prudent to target lower capacities of 220 mAh/g with these materials, as opposed to capacities above 250 mAh/g anticipated for the lithium-manganese rich (LMR)-layered-layered-composite (LLC) material. The designed composite structures with domains of layered and spinel phases were confirmed, the reviewer noted, through X-ray diffraction (XRD) and high-resolution transmission electron microscopy (HRTEM). The reviewer also noted a few good publications that had emerged from this project. The reviewer offered several comments, however. The reviewer asked why the magnesium (Mg)-doped, layered-layered-spinel (LLS), which showed higher capacity/rate capability, was not being pursued. Noting evidence for the local domains of spinel and layered phases, the reviewer asked if it would be possible to verify whether the spinel content (in the bulk) is close to the targeted 6%. The electrode loading should be mentioned/tracked here, the reviewer stated, as the performance is significantly reduced at high loadings with LLC cathodes. Finally, the reviewer questioned why the coating studies focused as much on lithium cobalt oxide ($LiCoO_2$) cathodes, rather than these cathodes directly.

Reviewer 3:

The reviewer said understand layered spinel structural cathode materials.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

Good collaboration, the reviewer said.

Reviewer 2:

There are good collaborations with several researchers from the Argonne National Laboratory and also with external researchers in understanding these materials at the fundamental level, the reviewer opined. However, the reviewer continued, it is probably more appropriate and timely to collaborate closely with the industry, especially the licensees (BASF, Toda, LG and Envia) to establish the merit/relevance of these materials compared to NCA (nickel cobalt aluminum oxide)-based cathodes or LMR-LLC cathodes.

Reviewer 3:

The principal investigator (PI) has developed collaborations with national laboratories, universities, and industries, the reviewer noted.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer described the proposed work as a good combination of theoretical modeling and experimental approach to continue improving layered-layered-spinel cathode materials.

Reviewer 2:

Current work of stabilization using spinel structure should be vigorously continued in combination with doping studies, the reviewer urged, while recommending that work related to coatings other than atomic layer deposition (ALD) should be de-emphasized. That work will in general be merely a Band-Aid and a sheer waste of resources, the reviewer asserted. In the reviewer's opinion, if a fundamental solution is not found, such as by manipulation of the bulk structure as pursued here, coatings, as has historically been seen from massive past work at Argonne National Laboratory (ANL), will not save the day for this cathode system. In conclusion, the reviewer recommended the modeling work be pursued collaboratively with groups possessing greater expertise.

Reviewer 3:

The reviewer described the proposed future research as continuing development of these LLS cathodes to optimize their capacity and electrochemical stability, and expanding the materials characterization techniques, e.g., through Raman spectroscopy and augmenting them with modeling studies to understand the bulk and interfacial structures of these materials. It is, however, equally important, the reviewer said, to demonstrate the benefits of these LLS cathode materials in an industrial environment in comparison with the surface-treated NCA-based cathode to properly assess the technical barriers in the Vehicle Technologies Office (VTO).

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

In the reviewer's estimation, this project has the highest relevance to the U.S. Department of Energy's (DOE) goal. In fact, the reviewer, elaborated, this is the only high-capacity cathode system that has any realistic chance of being deployed in the near future in automotive applications.

Reviewer 2:

The low specific energies and high costs of lithium (Li)-ion batteries are serious impediments to their widespread adoption in vehicles, the reviewer summarized, and high-capacity cathode materials are required to address these shortcomings. While LMR-LLC cathodes are promising from both energy and cost perspectives, the reviewer noted that they are hampered by issues such as voltage fade and hysteresis. Spinel embedded materials of this class, the reviewer speculated, may mitigate these issues, resulting in stable structures, as is being addressed in this project.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer recommended increasing project funding because this is the core program of the LL materials.

Reviewer 2:

The resources are adequate for the scope of the project, said this reviewer.

High-Capacity, High-Voltage Cathode Materials for Lithium-Ion Batteries: Arumugam Manthiram (University of Texas at Austin) - es051

Presenter

Arumugam Manthiram, University of Texas at Austin.

Reviewer Sample Size

A total of three reviewers evaluated this project.

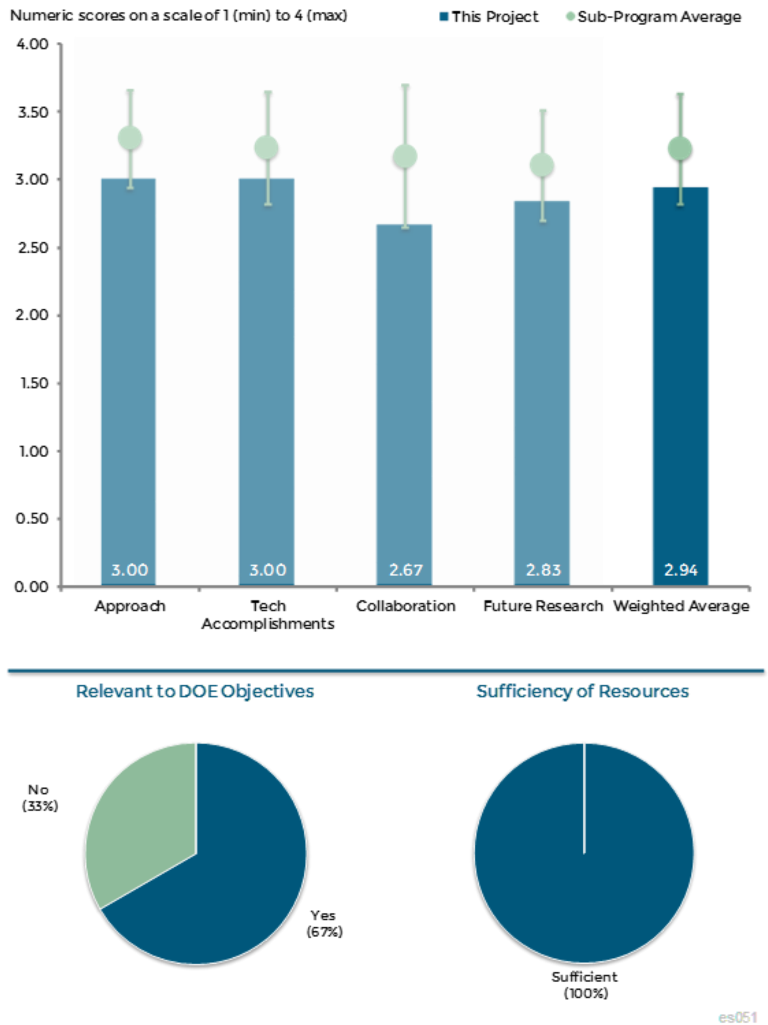


Figure 2-2 High-Capacity, High-Voltage Cathode Materials for Lithium-Ion Batteries: Arumugam Manthiram (University of Texas at Austin) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer praised the approach of exploring and characterizing vanadium (V)-based cathodes, especially from fundamental points of view, for the development of a higher-capacity cathode as an excellent idea. The reviewer acknowledged that it is high-risk work but said the effort to understand the structure/property relationship is of utmost importance to facilitate further studies.

Reviewer 2:

The reviewer remarked that the objective of this project is to develop new polyanion phosphate cathodes with high specific capacity for Li-ion batteries, exhibiting multi-electron redox process, and to gain a fundamental understanding of their structure/composition/performance relationships. The reviewer then enumerated the types of cathodes being developed; first, the three polymorphs of $LiVOPO_4$, wherein two lithiums can intercalate; second, nanostructured phosphate cathodes with either graphene inclusions of aliovalent metal dopings for enhanced conductivities and performance. Low-temperature synthesis methods are being developed for these cathodes to improve their ionic and electronic transport, the reviewer continued. Although the approach looks well-designed and feasible, the reviewer said, with these different cathode materials – $Li_3MCO_3PO_4$, $LiVOPO_4$ and doped $LiCoPO_4$ – it looks a bit diffuse. It is debatable, in the reviewer's opinion, if these cathodes (especially $LiVOPO_4$) could be a promising candidate for high-energy cathodes, with its low intercalation potentials for second lithium.

Reviewer 3:

The reviewer found the approach weak in that proposed materials – nickel, cobalt and V – are scarce and expensive. The reviewer also considered that capacities for materials were measured at unrealistically low rates. Should be C/3 as a minimum. The reviewer added that the potential for sodium intercalation may or may not be relevant to DOE program.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

While the $LiVOPO_4$ cathodes did not turn out to be promising, the reviewer said, the work the authors have carried out is exhaustive (various synthetic procedures, materials engineering, characterization, etc.) and contributes to a solid understanding of their properties and potential thus expanding the technical database. The reviewer termed discovery of the new layered $VOPO_4$ as also interesting and wondered if, as the author suggested, it can act as a host for sodium (Na) or Mg insertion.

Reviewer 2:

Interesting studies were made on the $LiVOPO_4$ cathode in three different crystallographic forms, the reviewer noted, demonstrating intercalation of more than one Li and capacity greater than 200 mAh/g, albeit at low voltages for the second Li, also confirmed from chemical lithiation. The reviewer also found it interesting to note that an aliovalent substitution of V^3+ for Co^2+ decreases polarization and increases the initial capacity to approximately 100 mAh/g, even without carbon (C) coating. Finally, the reviewer observed, three polymorphs of $LiCoPO_4$ have been synthesized by a facile microwave method (yet to be characterized) and that these studies also led to some good publications. Although in the reviewer's opinion a good understanding has been gained from the low-temperature synthesis (and characterization) of these advanced cathodes, the performance characteristics of these materials do not compare well with the layered cathodes.

Reviewer 3:

The reviewer noted that the materials studied in this project offer no improvements over existing cathode materials and found it very hard to understand the overall strategy. It appeared to the reviewer to be a program of trial and error, albeit intelligent trial and error. However, the reviewer considered that the theory behind the approach sounds good. The material kinetics were measured only at very low rates, the reviewer said, and may be hard to improve. The best candidate materials still have many unresolved problems, the reviewer noted in conclusion.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

More collaborative effort would have been desirable, in the view of this reviewer.

Reviewer 2:

The reviewer discerned no formal collaboration in this project so far. Although the work is rather exploratory, the reviewer said, some collaboration with external partners would be helpful.

Reviewer 3:

Noting that only one collaboration had been shown in the presentation, the reviewer believed the project was very weak in this aspect.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

Focused efforts to manipulate the electronic properties using conductive agents and synthetic procedures are certainly the right future directions, the reviewer agreed. The reviewer suggested work using materials that will have practical relevance, rather than focusing on high Co content compounds and cathodes with huge difference between the voltage plateaus, if any. On the other hand, the reviewer noted, work with Na and Mg could also be interesting.

Reviewer 2:

The reviewer described the proposed future research as to continue the development and study of the three polymorphs of $LiVOPO_4$ cathode and to down-select one for further study on the synthesis of $LiVOPO_4$/graphene nanocomposites to improve conductivity and thus increase the capacity to about 250 mAh/g. Likewise, the reviewer continued, aliovalent doping of M (in $LiMPO_4$; M= iron (Fe), Mn or Co) with V_3+ or Ti_4+ will be explored to improve their ionic/electronic conductivities. The proposed materials look interesting, the reviewer said, but the approach seems to be truly exploratory and non-specific. Nor do the expected improvements appear to be significant compared to some of the known layered, mixed metal oxide materials (Ni-rich or even the surface-treated NCA cathodes), in the reviewer's opinion. This reviewer agreed with a suggestion offered by another, that there should be more focus on improving the cycle life and rate capability of the $VOPO_4$ cathodes or, more important, on exploring newer cathode materials that can intercalate multiple Li-ions and/or provide higher capacity.

Reviewer 3:

Seeing no overall strategy for material selection and evaluation, the reviewer said the project appeared to rely on a cut-and-try strategy.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The low specific energies and high costs of Li-ion batteries are serious impediments to their widespread adoption in vehicles, the reviewer noted, thus, improvements in the specific energy of electrode materials will result in increased vehicle range and reduced battery cost. Because state-of-the-art cathode materials have low specific capacities due to intercalating only one Li per transition metal, the reviewer said, new cathode materials with an ability to intercalate multiple lithiums address this technical barrier.

Reviewer 2:

The search for alternative cathodes capable of multi-electron redox process is an important research topic to achieve significantly higher energy density cathodes, the reviewer observed, hence the topic is highly relevant.

Reviewer 3:

The reviewer expressed doubt that the project would result in any positive effect and found it unclear that any improved materials would be forthcoming.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer considered the funding level sufficient because the project is exploratory research.

Reviewer 2:

The resources are adequate, this reviewer said, for the scope of the project.

Reviewer 3:

The third reviewer said it was not clear how project milestones and resources were related.

Design of High-Performance, High-Energy Cathode Materials: Marca Doeff (Lawrence Berkeley National Laboratory) - es052

Presenter

Marca Doeff, Lawrence Berkeley National Laboratory.

Reviewer Sample Size

A total of three reviewers evaluated this project.

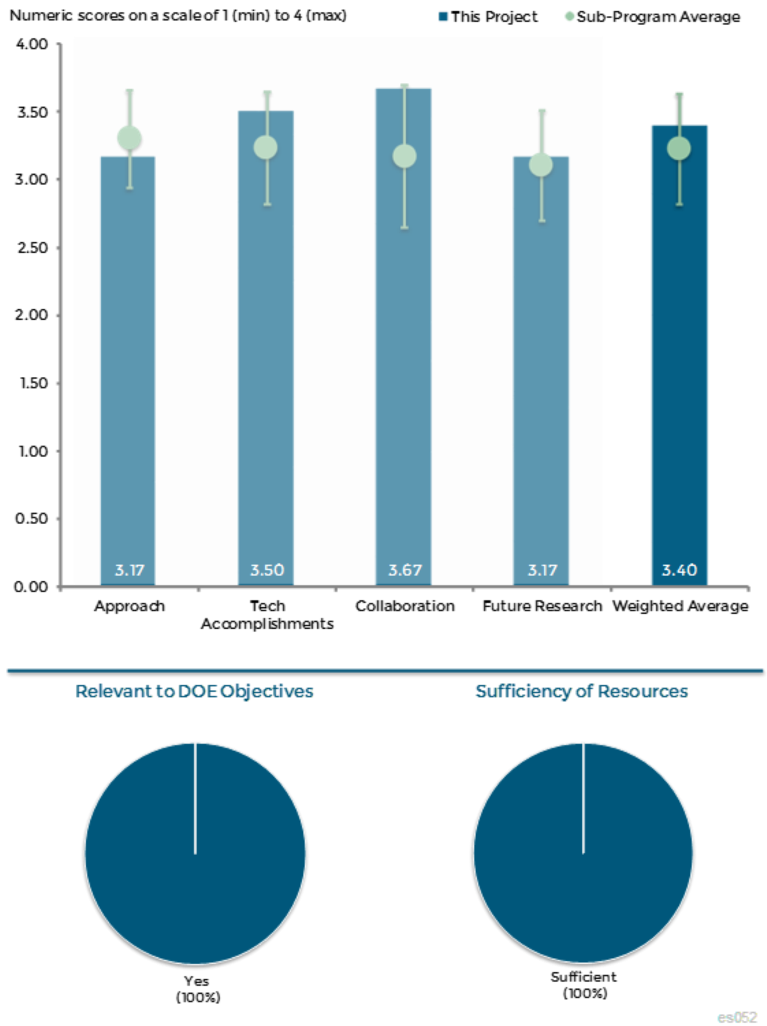


Figure 2-3 Design of High-Performance, High-Energy Cathode Materials: Marca Doeff (Lawrence Berkeley National Laboratory) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

Partial Ti-substitution for nickel manganese cobalt oxide (NMCs) cathodes increases the capacity and cyclability, the reviewer observed.

Reviewer 2:

The reviewer found the work narrowly focused on only one dopant and expressed a desire to it expanded to include series of dopants such as those of different oxidation states, for example, and evaluate their impact. The reviewer also thought the work should have included NMC of different compositions.

Reviewer 3:

In previous years, the reviewer said, this project showed that the aliovalent substitution of NMC cathode materials with titanium (Ti) results in improved capacities and cycle life, especially at high charge voltage. The objective this year, the reviewer said, was to understand the beneficial effects of Ti substitution in terms of the bulk and interfacial properties using a suite of advanced analytical techniques (synchrotron); to further develop the spray pyrolysis method to synthesize the NMC cathodes in a single step to control the morphology (hollow particles); and to examine the possibility of affecting a surface coating on the cathode particles. Alternatively, the reviewer noted, surface coating was implemented using additional ALD/molecular layer deposition (MLD) coating. The strategy of altering the bulk and interfacial properties of the NMC cathodes through suitable substitutions is feasible, in the reviewer's opinion, although, the reviewer qualified, not as novel as was claimed in the presentation. With the hollow morphologies possible thus far, the reviewer said, spray pyrolysis, although appealing from a process standpoint, may not be acceptable in terms of tap densities. Finally, the reviewer speculated, overlaying another coating on the cathode material with desired surface layer (through Ti substitution) may offset the benefits of Ti substitution.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:
Theoretical calculations have been verified with experiments, the reviewer observed.

Reviewer 2:
Although believing the studies were to some degree limited in scope, the reviewer complimented the authors for having done an excellent job in preparing and characterizing the materials, from both experimental and modeling points of view. The reviewer praised the results related to structural reconstruction during high-voltage cycling as very insightful and the conclusions as carefully drawn and well presented.

Reviewer 3:
Good progress has been made in understanding the compositional changes of the Ti-doped NMC cathodes both in the bulk and on the reconstructed surface layer, the reviewer said, noting that a few good publications have resulted from these studies. Some of the findings were, in the reviewer's opinion, quite expected; for example, that the surface reconstruction would occur in the first cycle and depend on the charge potentials. If the aliovalent Ti-substitution lowers the potential profile on discharge also, the reviewer remarked, that might offset the gain in capacity. Moreover, the reviewer continued, the longevity of Ti-substitution on the surface properties has yet to be established and the cycling data presented does not support the claim that the cycle life has improved. The reviewer noted noticeable capacity fade even with Ti-doped NMC. Finally, the reviewer wondered if the improved performance of the spray pyrolysis material might be due to higher surface area (hollow morphology). If so, the reviewer concluded that would imply increased electrolyte-affected degradation of the surface.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
This is an exemplary collaborative project, in the view of this reviewer.

Reviewer 2:
There is good collaboration with several researchers at Lawrence Berkeley National Laboratory (LBNL), the reviewer observed, as well as with external researchers, especially in carrying out the basic studies to understand the nature of the reconstructed surface layers. The reviewer raised the possibility that collaboration with an industrial partner could be useful to assess the benefits of this material in relation to several other NMC materials available within the industry.

Reviewer 3:
The PI has developed collaborations with many researchers at several national laboratories and universities, the reviewer noted.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The proposed future research is reasonable and operable, in this reviewer's estimation.

Reviewer 2:
The authors should move away from fancy synthetic routes such as spray pyrolysis to prepare core-shell, hollow structures, the reviewer recommended, as these will invariably be more expensive to manufacture and offer no apparent benefit in performance (with lower density). The reviewer also suggested the project team

explore higher Ni content materials using dopants and study their thermal behavior – a key drawback of this group of cathode materials. Recognizing that it is tempting to look for multiple solutions, the reviewer encouraged the project team to remain focused on a few key items such as substitutions and de-emphasize "me too" types of work such as coatings.

Reviewer 3:

The proposed future work for the balance of the project duration is to explore the composite core-shell structures, if possible, from the spray pyrolysis and with suitable surface coatings, the reviewer observed. Future studies in a new, related project, the reviewer added, will include NMCs with higher Ni content NMC compositions and the synthesis of core-shell materials using spray pyrolyzed hollow spheres.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer called the project very relevant, but believed that focusing on only one dopant limited its experimental scope.

Reviewer 2:

High-energy-density electrode materials are required to improve the specific energy of Li-ion cells and thus increase vehicle range and reduce battery cost, the reviewer said. The reviewer reiterated that state-of-the-art cathode materials provide capacities of only about 170 mAh/g, about half the capacities possible from the (C) anodes. There is a need explore new cathode materials, which this project is duly addressing, the reviewer concluded.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The funding level seems right, said this reviewer.

Reviewer 2:

The reviewer assessed resources as being adequate for the scope of the project.

First Principles Calculations of Existing and Novel Electrode Materials: Gerbrand Ceder (Massachusetts Institute of Technology) - es054

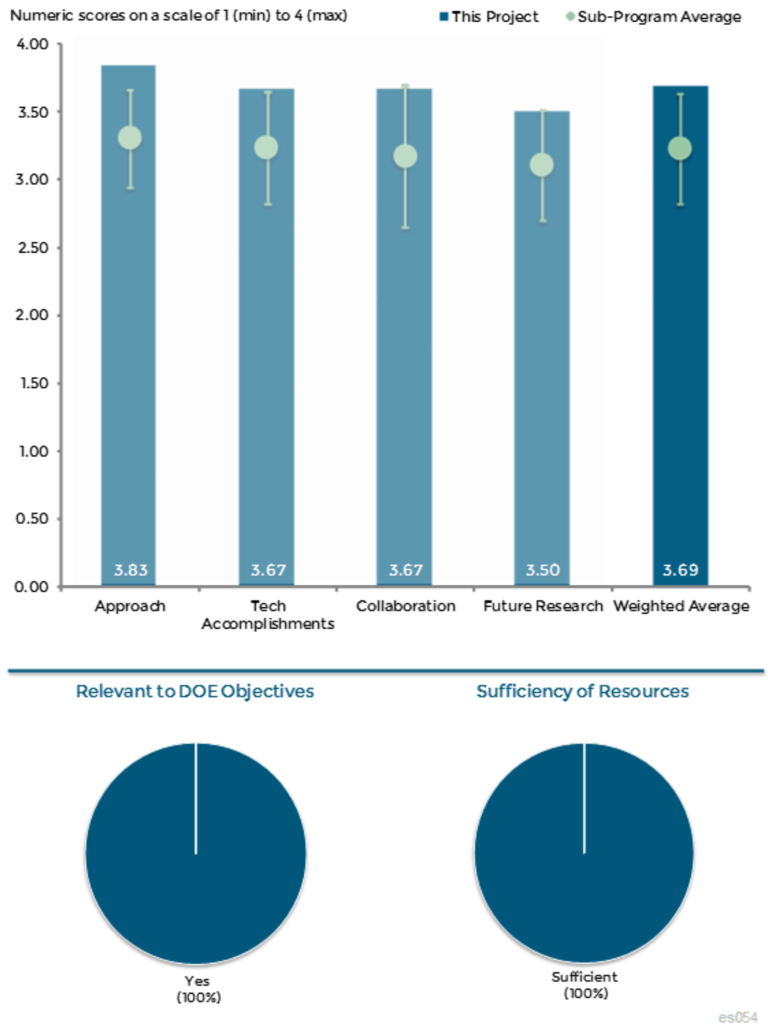


Figure 2-4 First Principles Calculations of Existing and Novel Electrode Materials: Gerbrand Ceder (Massachusetts Institute of Technology) - Electrochemical Energy Storage

Presenter

Gerbrand Ceder, Massachusetts Institute of Technology.

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

Seeking out new, high-energy-density positive electrode materials is a huge technical challenge, the reviewer said, adding that the PI is tackling this problem from mechanisms learned from predictive modeling.

Reviewer 2:

Noting that Li-excess, layered composite, transition metal oxide electrode materials are some of the most challenging material structures to study with first-principles calculations, the reviewer said the PI's approach was excellent, while also claiming not to be the best judge of this type of work.

Reviewer 3:

The reviewer called this a very interesting blend of theoretical work with experimental and practical work where new compounds are used to test the theoretical suggestions, and noted that it is very focused on the critical barriers.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The insights gained in this project are providing guidance to material innovation, the reviewer stated.

Reviewer 2:

The reviewer said the percolation concept the author found and later tested in practice is new and termed it a real accomplishment. Likewise, the reviewer found it very interesting to learn that a $Li(Li,Mn,Nb)O_2$, with a high degree of oxygen participation in the redox process, is a stable cathode material that does not fall apart as the electrode is cycled. The reviewer looked forward to hearing the mechanism behind this behavior explained in the future.

Reviewer 3:

While agreeing that the PI has done a significant amount of work and shown considerable progress, the reviewer was unclear on the PI's conclusion that over-lithiation should improve diffusion in these materials when the opposite is generally true. The reviewer also questioned some of the model compound choices, noting that, while they may be very interesting, they will never be in transportation-oriented batteries.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer remarked that the PI has a number of collaborations with other modelers and researchers examining these complex materials.

Reviewer 2:

Strong collaboration is clearly shown, the reviewer said, and, in particular, the strong correlation between theory and experimental results is very encouraging.

Reviewer 3:

Modeling and experiments are combined well in this project, the reviewer said.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer noted that the PI is planning to extend his present studies.

Reviewer 2:

The reviewer praised the establishment of the relationship of lattice expansion/contraction to diffusion as very insightful. It means, the reviewer went on, that there will be some strong coupling between stress and diffusion and because diffusion and concentration gradient will induce stress in the electrodes, the stress will in turn change diffusion. The reviewer wondered if strain engineering might provide another knob to tune the capacity and rate performance of the cathode materials. Also, the reviewer asked what the future development plan is for the new Li- excess materials, such as LMCO and $Li(Ni_{2/3}Sb_{1/3})O_2$.

Reviewer 3:

The area of oxygen participation in the redox process seemed to this reviewer to be very intriguing and in the reviewer's opinion, its relation to the oxygen loss is very important. If the authors managed to propose a mechanism for the loss of oxygen, that result, by itself, could be very useful, the reviewer predicted.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This project will lead to improved high-energy-density oxide electrode materials, the reviewer predicted, which should reduce costs and enable further electrification of the nation's vehicles, resulting in improved gas mileage.

Reviewer 2:

Yes, the reviewer said, in particular when talking about high-capacity cathode powders which are, at the moment, the most important active ingredient limiting the overall capacity of the Li- ion battery.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The PI is effectively using the available funds, the reviewer concluded.

Reviewer 2:
The resources are sufficient, the reviewer said, depending on how much experimental work is required.

First-Principles Calculations and NMR Spectroscopy of Electrode Materials: Clare Grey (University of Cambridge) - es055

Presenter

Clare Grey, University of Cambridge.

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

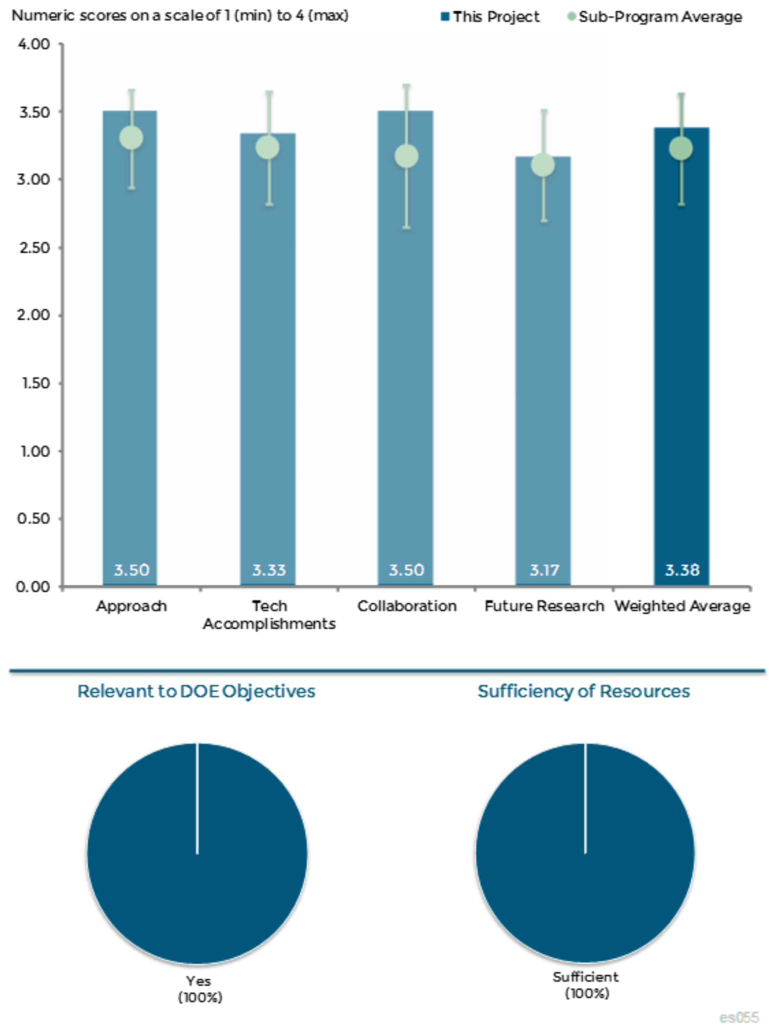


Figure 2-5 First-Principles Calculations and NMR Spectroscopy of Electrode Materials: Clare Grey (University of Cambridge) - - Electrochemical Energy Storage

Reviewer 1:

The project team is using carbon 13 (C13) to understand the composition and change with time of solid electrolyte interface (SEI) components, the reviewer noted, terming it an extremely valuable approach and highly relevant. Dr. Grey uses multiple techniques and collaborations to understand what is happening at the atomic and molecular level, the reviewer observed, and focuses on understanding how these insights relate to macroscopic battery behavior.

Reviewer 2:

The reviewer believed it safe to say that the PI is the world leader in conducting nuclear magnetic resonance (NMR) studies on batteries, battery components, and battery materials, having proven such studies can provide insights into battery operation and degradation mechanisms. There are others the reviewer believed are in the PI's class, most of whom worked with the PI at some point. The approach to this work, the reviewer said, represents the quality of this group of researcher. The only aspect the reviewer would question is the breadth of studies conducted under this effort, which the reviewer noted is attacking a lot of very difficult problems.

Reviewer 3:

The reviewer observed that the project investigated the SEI composition of silicon (Si) and studied the effect of FEC and VC on composition. Li-ion conductivity in SEI should be investigated using NMR, and noted that no study on electrode tortuosity was reported.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

This reviewer praised excellent conclusions and progress, but was unsure concerning the point of the Na anode diagnostics. Another valuable focus to consider in the future, the reviewer suggested, would be attempting to gather evidence for whether Si SEI is stable at a constant Voltage. Does the film passivate, the reviewer asked, or does it continue to grow, consuming Li and electrolyte components, even when the anode is held at a constant voltage (i.e., not cycled).

Reviewer 2:

The reviewer noted that the focus of the presentation was on the silicon electrode, and that work is also being conducted on other advanced battery chemistries. The reviewer did not always agree with the PI's conclusions, citing in particular the explanation of the hysteresis in Si cycling. Nevertheless, the reviewer applauded the fact that suggestions were offered concerning phenomena and mechanisms observed in these studies.

Reviewer 3:

The use of NMR to study the mechanism of Li-S is unique and innovative, the reviewer said, noting that the results were published in the Journal of the American Chemical Society (JACS), a top technical publication. But the reviewer perceived the research lacked focus.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The PI has extensive collaborations in the United States and around the world, the reviewer observed.

Reviewer 2:

The PI, the reviewer noted, has always focused on understanding the most relevant issues affecting a battery issue, and uses extensive collaborations to do that. Nine institutions were listed as collaborators, many with more than one researcher, the reviewer remarked, terming this excellent.

Reviewer 3:

The project has collaborated closely with several PIs to obtain Si nanowires, SEI and additives, the reviewer said.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer described the future planned work as very ambitious.

Reviewer 2:

The Si SEI work is excellent and highly relevant, the reviewer said, referring to earlier comments on whether the Si SEI is truly passivating. Another valuable focus, in this reviewer's opinion, would be trying to understand the effect of additives, such as FEC, on the SEI makeup. The reviewer was unsure about the purpose of the Na dendrite study, because Na offers no obvious benefit for transportation applications, in the reviewer's view.

Reviewer 3:

The reviewer suggested future work include study of Li-ion conductivity in SEI.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This project, the reviewer predicted, will lead to improved Li-ion and succeeding battery technologies, which should reduce costs and enable further electrification of the nation's vehicles, resulting in improved gas mileage.

Reviewer 2:

Referring to earlier comments, the reviewer deemed Si SEI understanding excellent.

Reviewer 3:

SEI is very important for cycling stability of Li-ion batteries, the reviewer opined.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The project has accomplished a tremendous amount of work and progress for a relatively small amount of funding, this reviewer said, adding a willingness to support further funding if that were requested.

Reviewer 2:

The reviewer described the PI as very productive and teaming with many colleagues.

Reviewer 3:

The PI has sufficient resources for the project, in the view of this reviewer.

Development of High-Energy Cathode Materials: Jason Zhang (Pacific Northwest National Laboratory) - es056

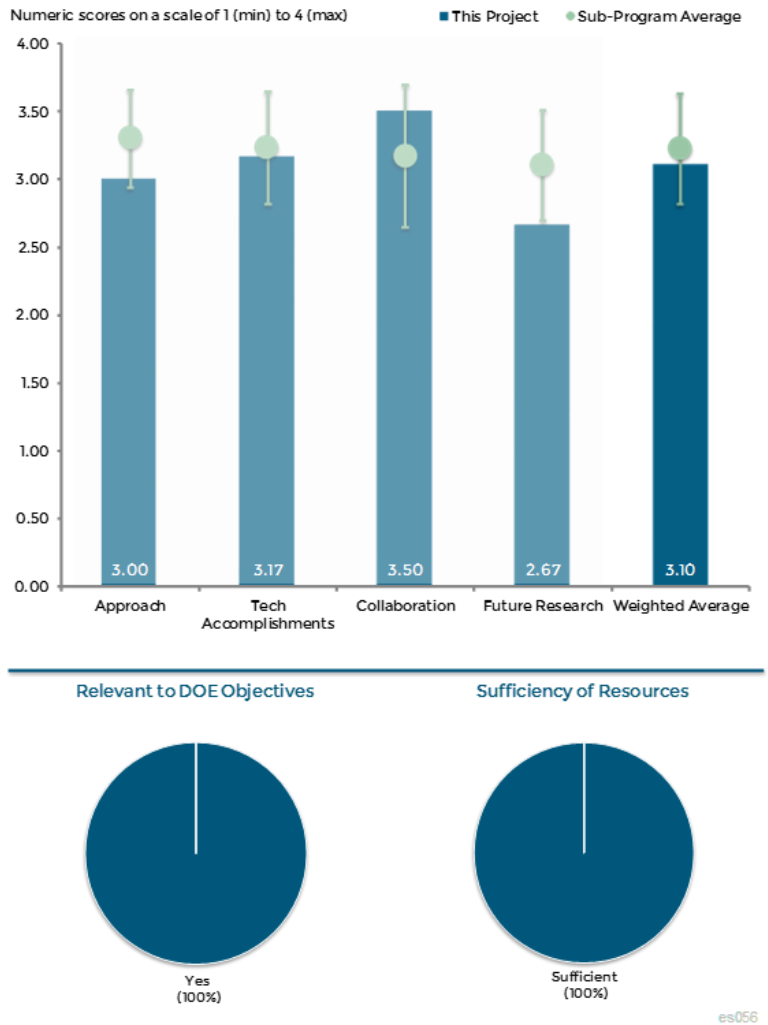


Figure 2-6 Development of High-Energy Cathode Materials: Jason Zhang (Pacific Northwest National Laboratory) - Electrochemical Energy Storage

Presenter

Jason Zhang, Pacific Northwest National Laboratory.

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The approach to understanding the behavior of Li_2MnO_3 in order to improve the voltage fade issue of LL cathode is a good one, the reviewer agreed, and the analytical tools employed were also very effective and complementary. The reviewer believed that the coating work did not have to be included, calling it kind of run-of-the-mill work.

Reviewer 2:

The reviewer described the objective of the project as being to understand the structural aspects and mechanisms contributing to capacity loss and voltage fade of LMR-LLC cathode materials and minimizing these processes by developing suitable surface coatings on the cathode materials. Additionally, low-cost synthetic methods for cathode materials were pursued. This project thus addresses one of the key performance barriers of LMR-LLC cathodes, adopts a viable approach and is well integrated with other efforts in understanding and mitigating voltage fade. However, the reviewer noted some elements that overlapped strongly with efforts on the same type of LMR-LLC cathodes or NMC cathodes, citing characterization of the surface layer as a disordered rock salt structure and noting its similarity to the reconstructed surface layer studies done at Lawrence Berkeley National Laboratory (LBNL). Further, the study of the aluminum fluoride (AlF_3) surface coating overlaps with efforts at ANL, the reviewer added, albeit with a different conclusion, namely that the surface coating reduces voltage fade – an apparent inconsistency with the overall program point of view. Finally, the reviewer regarded the focus on high-voltage operation of traditional NMC cathodes with 180 mAh/g somewhat unrelated.

Reviewer 3:

The reviewer recommended that targets should include maximizing use of low-cost materials and that use of cobalt and nickel needs be minimized. It was unclear to the reviewer what the overall technical goals were in a quantitative statement. While fundamental studies are a good idea, in the reviewer's opinion, general improvement is not a technical goal.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The team has done an excellent job in characterizing the behavior of Li_2MnO_3 during initial charging and subsequent cycling, the reviewer said, and data related to TM ion migration, structural change, effects of oxygen non-stoichiometry are also of high quality. The reviewer regarded the effects of coating as minimal and some of the cycling result-based statements as too preliminary to be highlighted.

Reviewer 2:

Good progress has been made in understanding phase transformations in a LMR-LLC cathode on cycling to a defect spinel and ultimately to a disordered, rock-salt structure, the reviewer noted, which is attributed to voltage fade. Such transformation is shown to be minimized by a surface coating of AlF_3 by reducing electrolyte-induced degradation. The reviewer also remarked on several good publications resulting from these studies. The reviewer considered these results interesting, observed that they imply the pseudo-spinel transformation of the LMR-LLC cathodes is surface-related, which is not consistent with observations by ANL and others. Phase transformation is more bulk phenomenon, the reviewer said, and cannot be controlled through surface modifications (coating). The study on oxygen non-stoichiometry to facilitate Li_2MnO_3 component appeared to the reviewer to accelerate voltage-fade degradation. Hydrothermal synthesis appears to provide slightly better performance, the reviewer noted, but recommended the comparison be made with materials of similar tap densities and of similar loadings. The cycle life data of the LMR-LLC cathodes the reviewer in general found impressive, but the loadings are still quite low (4 mg/cm^2), compared to the levels required in high-energy Li-ion cells. Unlike conventional cathodes, the reviewer said, performance of LMR-LLC cathodes depends strongly on the loading because of poor kinetics.

Reviewer 3:

Some improvements in performance and life have been achieved with coating technology, the reviewer remarked, but other improvements are a wash. Fundamental understanding should lead to more positive technical results, the reviewer said. Full control of phase transition from spinel to rock salt was not achieved, the reviewer noted, and bulk material properties were not modified.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

An excellent collaborative effort that also resulted in good, high-quality data, in the view of this reviewer.

Reviewer 2:

There are good collaborations with several researchers within DOE and elsewhere, the reviewer said, suggesting it is probably the appropriate time to collaborate with a battery manufacturer to assess the performance of these modified (hydrothermal assisted [HA] and coated) materials.

Reviewer 3:

The reviewer discerned good collaboration with the appropriate expertise at other institutions which supply needed capabilities.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer noted that the current project will end in a few months, at which time the focus will apparently shift to traditional (non-Li-rich) NMC cathodes to investigate the interface and bulk properties of both pristine and cycled cathode using advanced characterization techniques (especially operando TEM using liquid electrolyte). The objective will be to achieve high capacities of 200 mAh/g or more at high charge voltages and enhance the cyclic stability of such materials.

Reviewer 2:

The reviewer expressed approval of the overall goal but described the work plan as rather generic to improve on the high-voltage, high-capacity performance of NCM materials and asked what specific lessons (e.g., synthetic) learned from current research results will be applied in future work to tailor the properties of NCM cathodes so they it can be cycled effectively. A question also posed by the reviewer was what NCM compositions the project team is targeting. The reviewer observed that 200 mAh/g was cited as a goal, which means the material will invariably be Ni-rich. This, the reviewer said, is a tough problem to solve, not only from the cycling standpoint but also from the point of view of safety. The reviewer asked what specific ideas the project team have to resolve these issues and suggested the team select a high-payoff approach and pursue it exhaustively.

Reviewer 3:

The project does not have a clear end strategy growing out of results achieved to date (which the reviewer characterized as very modest), and, in the reviewer's estimation, needs to be more successful in terms of achieving performance and life.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

Yes, it does support DOE's goal, the reviewer said, as it addresses the improvement of capacity and stability of high-energy cathodes that are the bottlenecks for higher-energy cells.

Reviewer 2:

Low specific energies and high costs of Li-ion batteries are serious impediments to their widespread adoption in vehicles, the reviewer observed, and while LMR-LLC cathode materials are promising from energy and cost perspectives, they are hampered by issues such as capacity and voltage faced upon cycling. It is essential, the reviewer concluded, to improve the cycle life of these high-energy materials to make them suitable for EV applications, as is being done in this project.

Reviewer 3:

The project has to be more successful in achieving high performance and life from new materials, in this reviewer's opinion.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The funding level is sufficient, the reviewer reaffirmed.

Reviewer 2:

The resources are adequate for the scope of the project, said the reviewer.

Reviewer 3:

The reviewer found it very difficult to tell how resources and milestones are related.

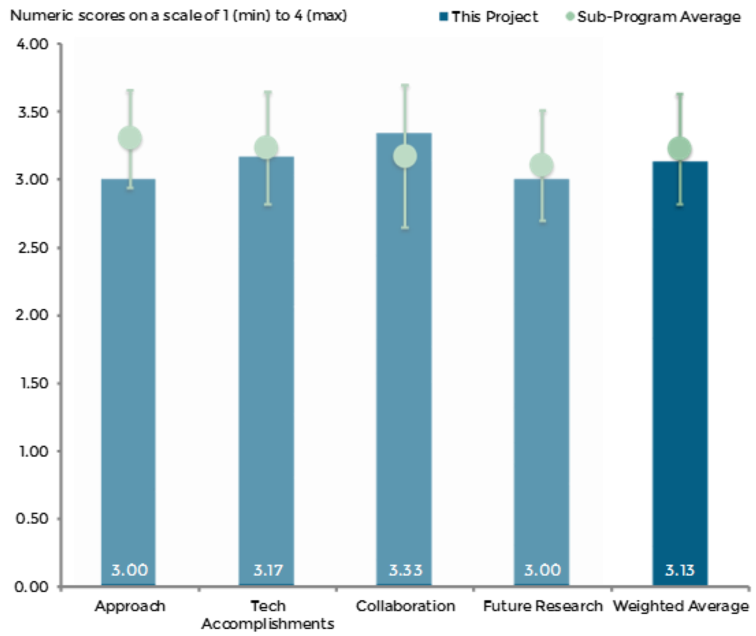
Advanced In-Situ Diagnostic Techniques for Battery Materials: Xiao-Qing Yang (Brookhaven National Laboratory) - es059

Presenter

Xiao-Qing Yang, Brookhaven National Laboratory.

Reviewer Sample Size

A total of three reviewers evaluated this project.



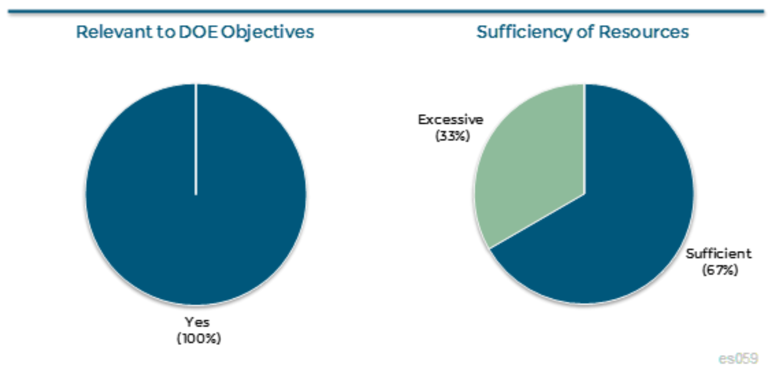


Figure 2-7 Advanced In-Situ Diagnostic Techniques for Battery Materials: Xiao-Qing Yang (Brookhaven National Laboratory) - Electrochemical Energy Storage

Question 1: Approach to performing the work–the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer lauded in situ and ex situ x-ray diagnostic techniques as tremendously valuable for understanding the structural changes that battery materials undergo both during cycling and under abuse conditions.

Reviewer 2:

A set of characterization tools including the time-resolved X-ray diffraction (TR-XRD), mass spectroscopy (MS), in-situ XRD and X-ray absorption spectroscopy (XAS), high-resolution transmission electron microscopy (HR-TEM) are used to study the crystal structure, electronic structure and chemical structure, the reviewer observed, predicting that these unique analytical techniques will enable better understanding of the underlying mechanism of thermal stability of metal oxide cathodes in the Li batteries.

Reviewer 3:

The goal of in-situ diagnostic techniques is appropriate, the reviewer agreed, but pointed out that the XAS, XRD and TEM cannot be done without highly specialized equipment and thus are unlikely to assist the average manufacturing operation without serious investment. Accordingly, the reviewer went on, there must be a clear linkage back to operational parameters, which has not been done. This had the effect of making the research appear quite academic to the reviewer, when in reality it could be quite applicable. The approach and milestones line up to each other, the reviewer said, but not to the stated relevance and project objectives. The broader impact of this work was not clear to the reviewer, who summarized by calling it is interesting research that is being judged against inappropriate criteria at its own behest.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The project has shown reasonably good progress, the reviewer said.

Reviewer 2:

A new unit-cell-breathing mechanism for Li_2MoO_3 during charge-discharge has been discovered using the synchrotron-based XRD, XAS and STEM and the corresponding results published in a prestigious journal, the reviewer recounted. Blended $LiMn_2O_4$ (LMO)-$LiNi_{1/3}Co_{1/3}Mn_{1/3}O_2$ (NCM) cathode materials with different stoichiometric ratios have been studied. The discovered specific physicochemical processes in the LMO and NCM should be described clearly in the annual report, the reviewer urged.

Reviewer 3:

The authors, the reviewer observed, have been prolific publishers, which reflects that their progress has been well recognized by their peers. The reviewer found the work and graphics quite interesting and potentially impactful. The concern expressed in an earlier comment, the reviewer said, was largely related to messaging, and not intended as an indictment of great research. The analysis of unit cell breathing is quite extraordinary, the reviewer said, predicting it could potentially lead to great insights in the design of future battery technologies. In the reviewer's opinion, the key element in the characterization is offering advice to the general battery community on how to produce better cathodes ($LiNiMnO_4$), but as this project nears completion it was not clear that this key outcome is being prioritized.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The results coming out of this project have benefited from the extensive collaboration network built by the PI, said the reviewer.

Reviewer 2:

The loss of key equipment at Brookhaven has led to a number of fruitful collaborations with laboratories and partners around the country, the reviewer observed, and the work has also engaged industry partners, which is key to transitioning diagnostic techniques out of the lab. Active engagement of the broader battery community is a key strong point of this work, in the opinion of this reviewer.

Reviewer 3:

While the reviewer saw evidence of a lot of collaboration, there appeared to be none with any of the groups supporting DOE VTO to develop high-energy batteries for automobiles. The reviewer recommended much more collaboration with other national laboratories, universities and battery companies working on novel materials or cells that meet DOE electric vehicle (EV) or plug-in hybrid electric (PHEV) goals.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer recognized that providing guidance is called out in the fiscal year (FY) 2016 proposed work, which the reviewer views as critical to project success. To have a meaningful impact, the reviewer continued, the work must rationally influence process design. Likewise, the reviewer recognized that this work is a natural continuation of ongoing work, but was critical of its apparent academic bent. To ensure that it has an appropriate impact, the reviewer asserted that there needs to be a focus applied after the proposed work.

Reviewer 2:

Several critical issues have been proposed by the research team, the reviewer noted. For example, the X-ray absorption near-edge structure (XANES) and the extended x-ray absorption fine structure (EXAFS) will be used to study the Mo K-edge of Li_2MoO_3 at different charge-discharge states. The transmission x-ray microscopy technique will be developed to investigate the three-dimensional element mapping of layer-structured cathode materials in the Li-ion battery research. The electronic structure and crystal structure at the atomic local range and long range of cathode material remain unclear, the reviewer observed, but if successful, the proposed future research will fill the critical knowledge gap in this field.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

Predicting that deployment of high-voltage cathodes will be critical to increasing the power and energy densities of battery packs, the reviewer said this work should aid in this process of electrifying vehicle transportation.

Reviewer 2:

The reviewer foresaw that the fundamental knowledge obtained will provide the guidelines for designing cathode material of Li-ion batteries and called the ongoing research well aligned with the mission and the objective of DOE's program.

Reviewer 3:

The reviewer failed to see much relevance in the work on Li_2MoO_3. Although its theoretical capacity is high, molybdenum is not particularly abundant, and its reaction potential is quite low.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

Acknowledging that the diagnostic tests are particularly time-consuming, the reviewer found the lack of a key focus on impactful conclusions for this amount of money disheartening.

Development of Novel Electrolytes and Catalysts for Li-Air Batteries: Khalil Amine (Argonne National Laboratory) - es066

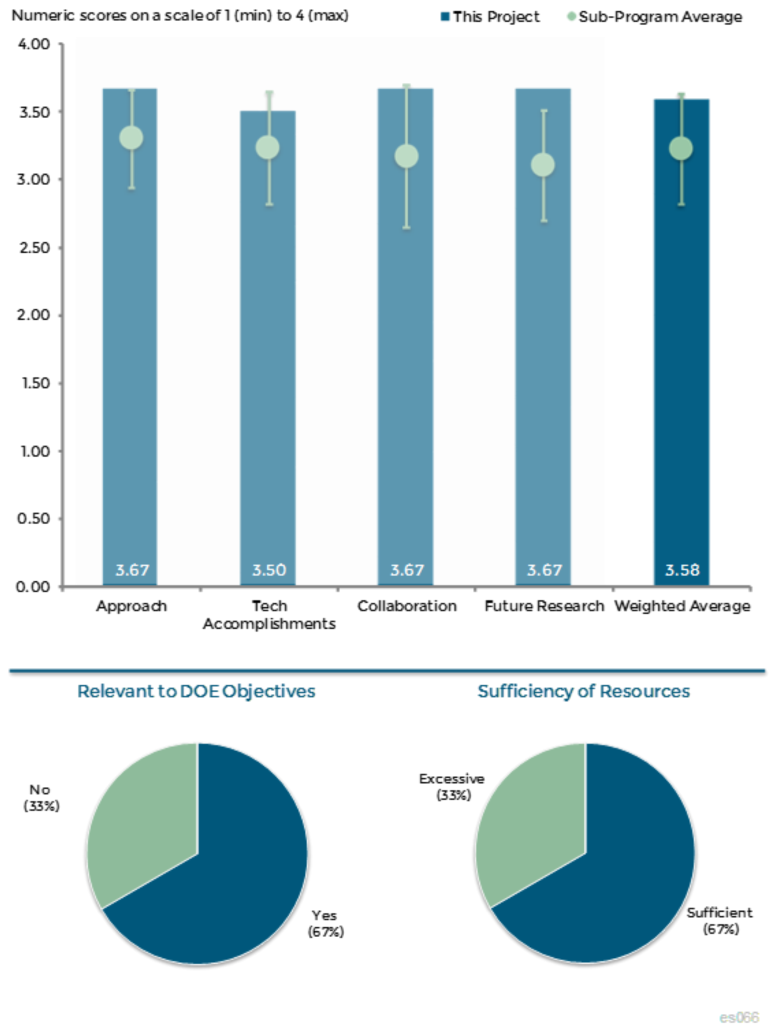


Figure 2-8 Development of Novel Electrolytes and Catalysts for Li-Air Batteries: Khalil Amine (Argonne National Laboratory) - Electrochemical Energy Storage

Presenter

Khalil Amine, Argonne National Laboratory.

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:
The project team is employing a good approach for developing catalyst and electrolyte for Li-air battery, in the view of this reviewer.

Reviewer 2:
The investigators adopted a creative approach to use the simulation design first, then with experimental testing, the reviewer observed, and its efficiency and effectiveness were demonstrated in their catalyst, electrode and electrolyte investigation for Li-air batteries.

Reviewer 3:
A very well-designed project focused on delivering timely results, said the reviewer.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:
A few good electrolyte and electrode structures (including catalyst) were investigated and good performance was demonstrated toward the project goals with all the milestones are successfully reached, the reviewer summarized.

Reviewer 2:
All tasks are on schedule and good use has been made of the theoretical and experimental tools, said the reviewer.

Reviewer 3:
Palladium (Pd) and molybdenum carbide (Mo_2C) catalysts are expensive, the reviewer observed, recommending that cheaper alternatives be developed and the result be demonstrated in a full cell configuration.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer cited good interaction and collaboration.

Reviewer 2:
The PI established wide international collaboration ranging from universities to national laboratories, the reviewer said.

Reviewer 3:
The results and the use of the characterization tools speak highly of the team, the reviewer commented.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The proposed future research is solid and based on current achievements, the reviewer said.

Reviewer 2:
Proposed future work is focused on the results and data interpretation of work conducted to date, the reviewer said.

Reviewer 3:
Noting that development of new electrolytes and cathodes was proposed, the reviewer saw no strategy explained for developing materials nor what sort of materials were envisioned.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer said reduce use of petroleum.

Reviewer 2:
The research for Li-air is in line with the objective of reaching high energy-density batteries to replace petroleum in vehicles, according to the reviewer.

Reviewer 3:
The recent DOE publications clearly state the fundamental limitations of the Li-air system that do not have clear solutions, the reviewer observed, which makes it important to support high- performing teams like this one to continue the search for new approaches.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The PI has adequate resources to achieve the milestones and goals of the proposed project, this reviewer said.

Reviewer 2:

The reviewer praised both the team and their access to characterization tools as excellent.

Design and Scalable Assembly of High-Density Low-Tortuosity Electrodes: Yet-Ming Chiang (Massachusetts Institute of Technology) - es071

Presenter

Yet-Ming Chiang, Massachusetts Institute of Technology.

Reviewer Sample Size

A total of four reviewers evaluated this project.

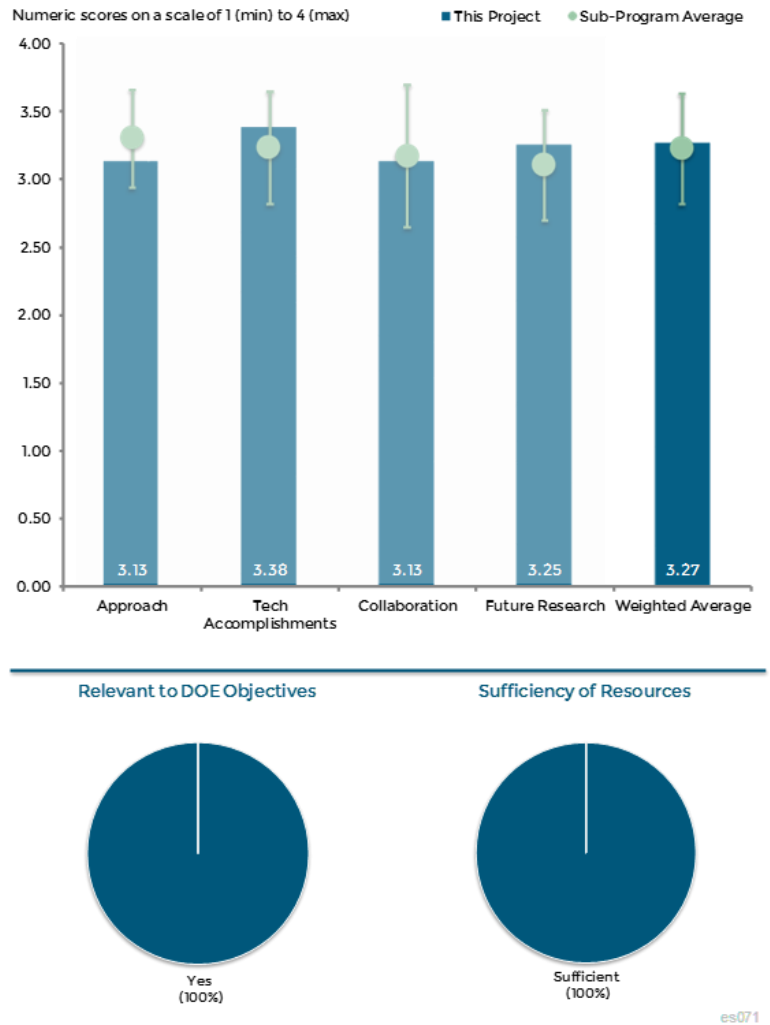


Figure 2-9 Design and Scalable Assembly of High-Density Low-Tortuosity Electrodes: Yet-Ming Chiang (Massachusetts Institute of Technology) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The objective, the reviewer explained, is to develop a high-density, binder-free, low-tortuosity electrode using two approaches: directional freezing and magnetic alignment. Two alternative methods, sintered and non-sintered, are used for directional freezing. Sacrificial solids and emulsion chaining are investigated for magnetic alignment. The electrode tortuosity can be adjusted by these fabrication methods over a certain range. Low tortuosity electrodes appear to have better high-rate performance. Remaining challenges and barriers have been correctly identified, the reviewer said, and the proposed future work is well-planned and feasible.

Reviewer 2:

The technical approach is excellent in addressing the technical barriers to increase usable area capacity, the reviewer said.

Reviewer 3:

The reviewer believed that some aspects of the approach are very good and quite innovative, but found it difficult to see how any of the techniques being developed could be carried out at high speeds in a cost-effective manner, especially when compared to the current method of making electrodes. The reviewer expressed a secondary concern about the magnetic alignment technique because it leaves an iron contaminant that may cause problems during battery cycling.

Reviewer 4:

The target of thicker, high-performing electrode structures is an important one from a cost perspective, the reviewer said, and the concepts utilized are unique and interesting. However, unfortunately the reviewer found it difficult to determine whether the cost advantage could be attained with either rather complicated process technology at a commercial scale.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

Good progress has been made to the PI's goals, including some very good diagnostic studies, in the reviewer's opinion.

Reviewer 2:

It will be interesting, the reviewer said, to see the stability of the porous matrix during cycling at higher temperatures.

Reviewer 3:

The reviewer expressed a desire to have seen the performance characterization done against control electrodes of the same loading and made with traditional methods. The reviewer found it difficult to determine absolute levels of progress from the current data presented.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

Collaborations appeared to the reviewer to be highly effective, particularly in introducing novel electrode fabrication methods such as the magnetic alignment approach.

Reviewer 2:

The PI has limited collaboration in the fabrication area, where support is needed, in the reviewer's estimation.

Reviewer 3:

Collaboration is minimal, the reviewer perceived, which was perhaps justified at such an early stage of development.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer considered that, generally, the overall plan is good but expressed concern that one of the big problems with these three-dimensional architecture electrodes is attaching the electrode to the current collector, which has yet to be addressed.

Reviewer 2:

The reviewer hazarded that the PI may address several questions the review panel members and the general audience raised at the end of the presentation, such as how to attach electrodes made by directional freezing and magnetic alignment to the conductor; electrical field singularities at the pore openings; scaling laws for heat and mass transfer; and viscosity effects on the electrode microstructure and thickness.

Reviewer 3:

Finding the technical goals satisfactory, the reviewer suggested it could be valuable to begin to assess certain commercial attributes before the research gets too far advanced. These could include issues of cost, robustness etc.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This project will lead to more optimized electrode microstructures, the reviewer predicted, improving both the energy efficiency and the cycle life of batteries. Ultimately, this could lead to reduced battery costs enabling further electrification of the nation's vehicles and improved gas mileage.

Reviewer 2:

This project directly supports fulfilment of DOE objectives, the reviewer said.

Reviewer 3:

Referring to earlier remarks, the reviewer said that, essentially, thick, high-performance electrode structures could be a significant boost to cost-effective designs.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The PI has sufficient funds to meet his goals, the reviewer said, but the project will likely need further funding if it is worthy of bringing to production.

Interfacial Processes in EES Systems Advanced Diagnostics: Robert Kostecki (Lawrence Berkeley National Laboratory) - es085

Presenter

Robert Kostecki, Lawrence Berkeley National Laboratory.

Reviewer Sample Size

A total of three reviewers evaluated this project.

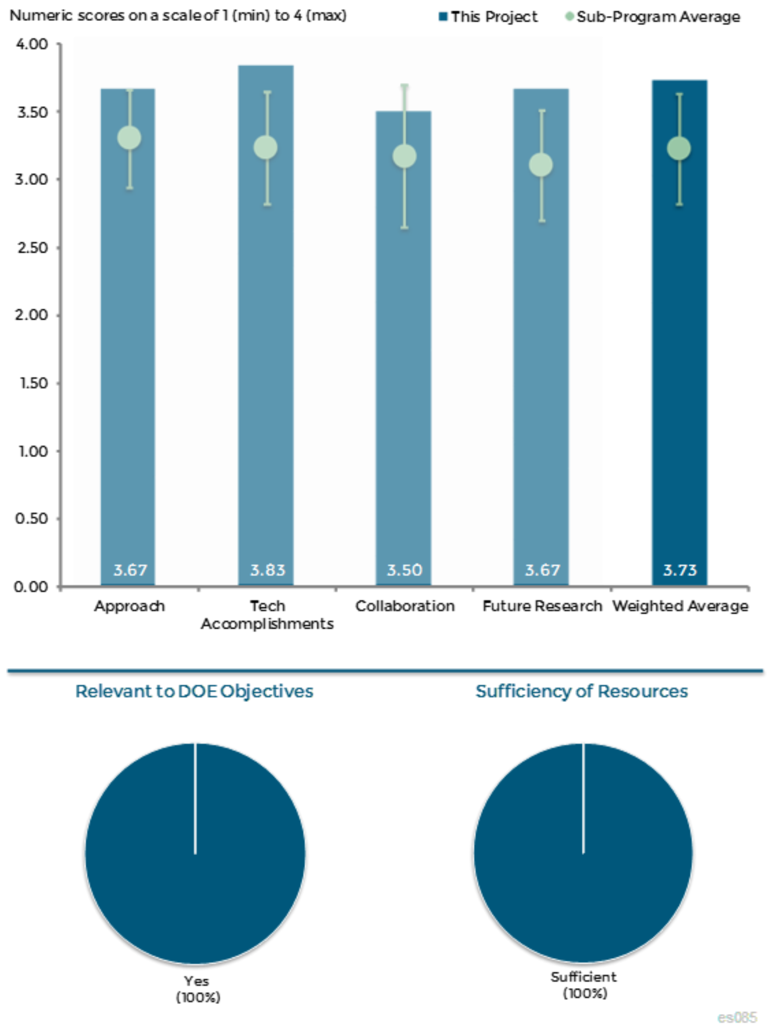


Figure 2-10 Interfacial Processes in EES Systems Advanced Diagnostics: Robert Kostecki (Lawrence Berkeley National Laboratory) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

Use of in situ and ex situ Raman, fluorescence, Fourier transform infrared (FTIR), x-ray absorption spectroscopy/microscopy to study the capacity decay mechanism is critical to achieving long cycle life for Li-ion batteries, the reviewer opined.

Reviewer 2:

On the subject of metal dissolution from high-voltage cathodes, the reviewer noted that X-ray absorption, fluorescence spectroscopy and Raman spectroscopy have been used to identify compounds that form during cycling of cathode materials and said that gaining this knowledge is critically important for suppressing degradation of cells based on LMNO and NCM cathodes and Li, graphite and Si anodes. While not unique, the reviewer said, it is clearly very solid and has been found to be very successful for this study. The reviewer also noted that the project includes in-situ study of the surface coating on Si anodes and Li salts on SEI formation on Si using FTIR.

Reviewer 3:

Using diagnostic techniques to understand interfacial processes and structures is excellent, the reviewer said, and the PI uses a large number of advanced diagnostic techniques to provide insight into what is happening at battery interfaces. The reviewer questioned the value of fluorescence, as it is so general, providing very little quantitative information about interfacial species or even their abundance.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer noted the interesting result about the cause of impedance rise at the anode in Mn cathode-containing cells. It would be interesting to see, the reviewer said, if the use of electrolytes without carbonate esters results in a significant reduction in impedance rise at high temperatures in Mn cathode-containing cells. A next step here that would be very welcome in the battery community, the review stated, is a proposal for mitigating or eliminating this impedance rise mechanism. The reviewer was enthusiastic about the use of laser induced breakdown spectroscopy (LIBS) to study and understand the Si SEI and expressed interest in seeing how the Si SEI changes as the material is held at a constant voltage for varying lengths of time, to determine if the Si SEI is passivating and, if not, how the film changes with time, if at all.

Reviewer 2:

The formation of β-diketones ligands and metal complexes is an important finding, which explains the shuttle reaction from cathode to anode and dissolution of transition metals in cathode, the reviewer said. The new findings open a new opportunity to improve the cycling stability of Li-ion battery cells.

Reviewer 3:

Unique insights on compounds formed during transition metal dissolution have been identified and the mechanisms of their formation have been proposed based on the combination of experimental and modeling techniques, the reviewer noted. The formation of beta-diketones ligands and transition metal complexes has been explained and their impact on SEI formation and cell performance has been proposed. Insoluble metal complexes formed on the cathode surface may form a potentially insulating film, and the reviewer felt it would be desirable to characterize the conductivity of such a film in the future. A second possibility is that soluble metal complexes may migrate and damage the SEI and/or impede Li transport within the SEI. Here, the reviewer expressed a desire to see a future study of the possible degradation routes in the future. The reviewer considered that the project results to date have been quite outstanding. Gaining this critically important understanding, the reviewer predicted, will have a major impact on stabilizing transition metal oxide cathodes in Li ion batteries. Si SEI composition studies resulted in some insights, although some of these have been suggested previously and discussed by others. The reviewer summarized the project’s findings by noting that lithium bisoxalatoborate (LiBOB) addition to the electrolyte was suggested to promote oligomer/polymer SEI formation on the Si surface, which slows down SEI growth. And that neither nanoscale distribution of the components within the SEI nor SEI thickness is uniform. SEI was found to depend on the local Si/coating structure and morphology (e.g., aluminum alkoxide coating promotes formation of more organic components within SEI). It would be nice, the reviewer said, to gain more insights in the future on why different coatings had such impacts.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

LBNL has a large number of extensive collaborations with universities, other national laboratories, and battery companies, the reviewer stated.

Reviewer 2:

The PI has collaborated with multiple PIs in this program including the scientists at LBNL, ANL, NREL, etc., the reviewer noted.

Reviewer 3:

Multiple international and national collaborations have been successfully established, but the coordination within the collaborative network has not been spelled out clearly, in the view of this reviewer.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

Calling the future research logically outlined and focused on overcoming critical barriers, the reviewer expressed a keen personal interest in learning more about the properties of the films formed on the cathode, the exact mechanisms of SEI damage by the metal complexes and why the SEI composition is strongly affected by the anode surface structure, morphology and composition.

Reviewer 2:

The reviewer expressed support for the move to understand high voltage stability in Ni-rich NMCs and encouraged the PI to confer with U.S.-based battery manufacturers, as many of them are also moving much of their focus to Ni-rich NMCs cathodes.

Reviewer 3:

The reviewer suggested studying the effect of Me (β-diketone) complexes on the conductivity (ionic/electronic) of SEI layers, on both anodes and cathodes.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The mechanism of capacity decay for cathode and anode in Li-ion batteries is a critical to develop long-cycle-life Li-ion batteries, the reviewer said.

Reviewer 2:

The successful use of high-capacity materials will contribute to the reduction of Li ion battery cost, which should further promote electric vehicles on the road to replace regular gasoline-engine-powered vehicles, the reviewer stated, making this project absolutely supportive of DOE's goal.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

LBNL has enough resources to conduct proposed future research, the reviewer commented.

Reviewer 2:

The resources are adequate, the reviewer reiterated.

Predicting and Understanding Novel Electrode Materials from First Principles: Kristin Persson (Lawrence Berkeley National Laboratory) - es091

Presenter

Kristin Persson, Lawrence Berkeley National Laboratory.

Reviewer Sample Size

A total of three reviewers evaluated this project.

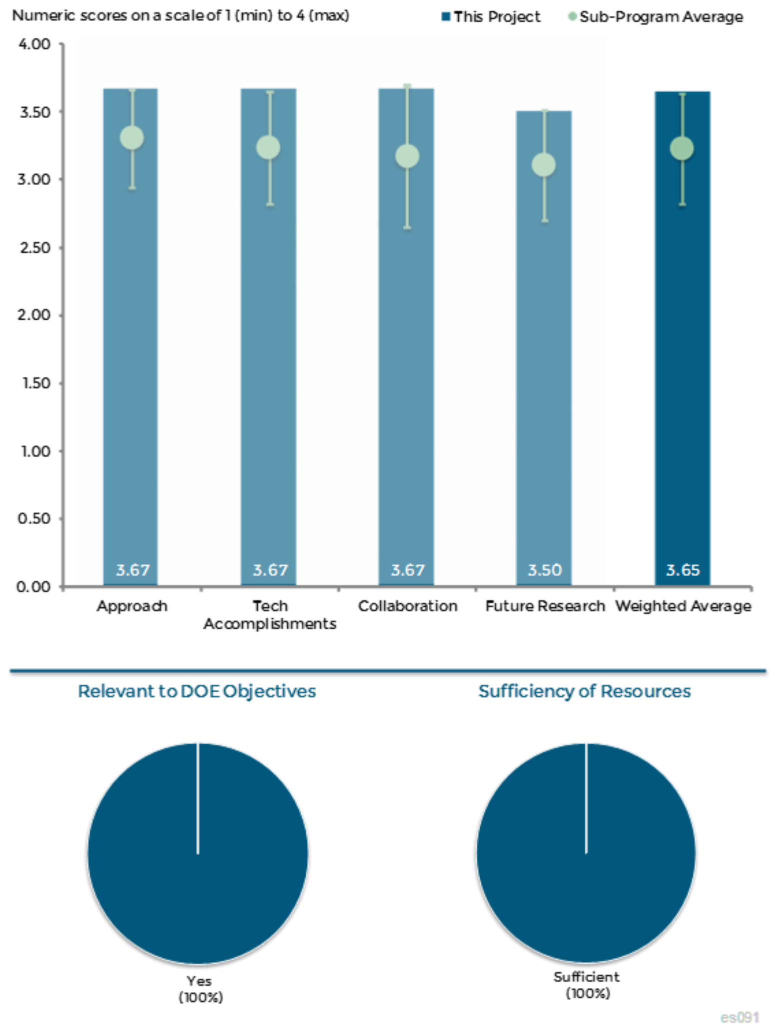


Figure 2-11 Predicting and Understanding Novel Electrode Materials from First Principles: Kristin Persson (Lawrence Berkeley National Laboratory) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The approach is clear and focused and studying the structure and stability of the Li_2MnO compound as Li is removed from the structure is the right approach, the reviewer agreed, and is giving additional information about the voltage fade mechanism.

Reviewer 2:

This work is focused on understanding the voltage decay of a promising high-capacity cathode material via predictive modeling, the reviewer observed.

Reviewer 3:

The LMR-NMC electrode materials are some of the most challenging material structures to study with first-principles calculations, the reviewer remarked, and as one of the end members of the composite structure, Li_2MnO_3 is quite relevant. While disclaiming specific expertise in the area, the reviewer called the PI's approach very good. However, the reviewer added, the literature indicates that Li_2MnO_3 domains within the composite structure cycle quite differently from the bulk material. Thus, extending this work to the actual composite structure may be a challenge.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The project team have produced extensive results on the cycling of the Li_2MnO_3 active material, the reviewer noted.

Reviewer 2:

The reviewer found the plots showing the stability of the Li_2MnO_3 structure moving toward a structure wherein Mn is displaced into the Li layer compelling and called the different kinetic behavior toward oxygen release between a surface oxygen and oxygen in the bulk very interesting. At some point, the reviewer said, it will be interesting to know additional details of the redox process involving oxygen. The new edge path proposed for Mn^{4}+ migration is a nice accomplishment that can be used for the design of high-capacity materials.

Reviewer 3:

The modeling work provided a coherent picture of how lithiation occurred in the Li_xMnO_3 phase, as part of the Li-excess cathode materials, the reviewer stated. The reviewer was left with two questions on the simulation results. The first referred to Slide 10, where the modeling work successfully explained the voltage difference between the first charge and discharge curves. However, the experimental work also showed large difference in the charge and discharge capacity. The reviewer asked can the modeling work shine some light on this issue. On Slide 9, oxygen evolution was predicted to occur when x was greater than one (Li_xMnO_3). However, based on the open-circuit voltage (OCV) comparison, it seemed to the reviewer that the discharge capacity was given by x greater than one, where x varies between two and one. The reviewer's question was whether this mean no oxygen vacancy will be generated during the activation process and can oxygen evolution be simulated along with the Li removal.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The project team has a number of collaborations with other modelers and researchers examining these complex materials, the reviewer noted.

Reviewer 2:

It seemed to the reviewer that collaborations with the Massachusetts Institute of Technology (MIT) and ANL teams are going very well.

Reviewer 3:

Excellent collaborations and synergies with other DOE laboratories and industry were noted by this reviewer.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The PI plans to wrap up studies on Li_2MnO_3, the reviewer noted.

Reviewer 2:

Additional investigation of the oxygen participation in the redox process seems very important, as it is strongly related to the evolution of stable or unstable crystal facets as a function of O_2 from the surface, the reviewer stated.

Reviewer 3:

The reviewer repeated the earlier question of whether oxygen evolution can be simulated along with the Li removal.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This project will lead to improved high-energy-density oxide electrode materials, which should reduce costs and enable further electrification of the nation's vehicles, resulting in improved gas mileage, the reviewer predicted.

Reviewer 2:

The project is shedding light on the stability and potential improvements that can be introduced into high-capacity cathode powders. That, the reviewer continued, is very related to petroleum displacement, as it will enable higher capacity batteries

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The PI has been very productive, the reviewer noted.

Reviewer 2:

Resources seem to be sufficient, the reviewer said, adding that based on the data and new information produced in this project, those resources seemed to have been well expended.

Studies on High-Capacity Cathodes for Advanced Lithium-Ion Systems: Jagjit Nanda (Oak Ridge National Laboratory) - es106

Presenter

Jagjit Nanda, Oak Ridge National Laboratory.

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

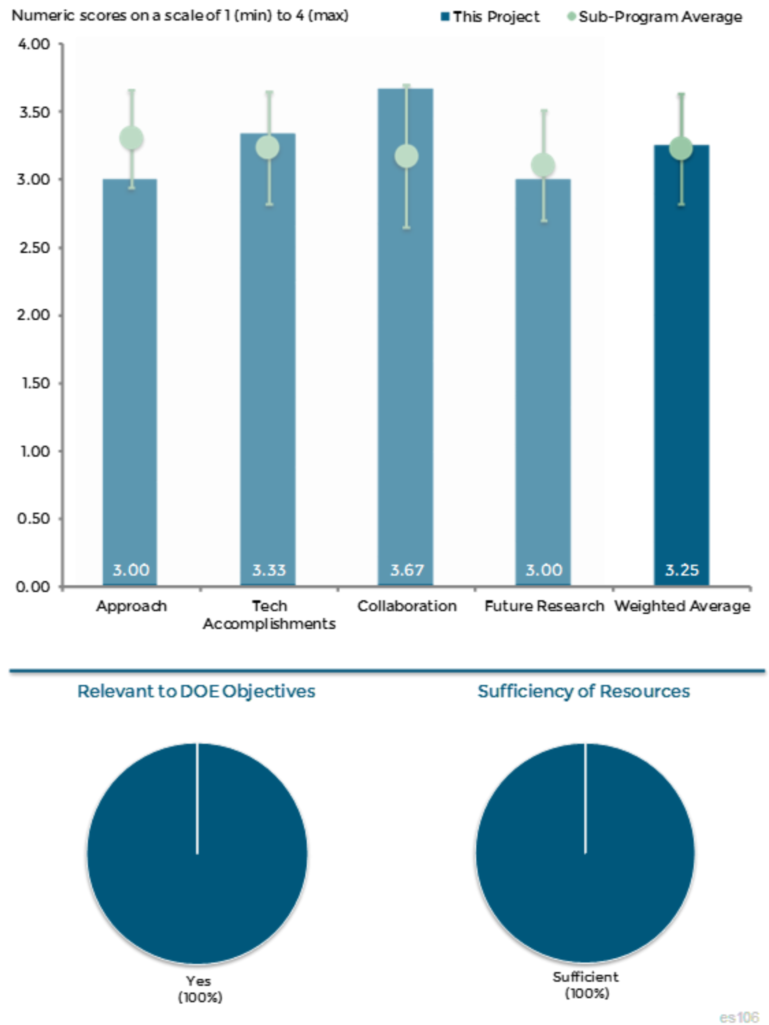


Figure 2-12 Studies on High-Capacity Cathodes for Advanced Lithium-Ion Systems: Jagjit Nanda (Oak Ridge National Laboratory) - Electrochemical Energy Storage

Reviewer 1:

The project, in the reviewer's opinion, had two key tasks that were not necessarily interrelated, potentially resulting in the project's impact being diluted.

Reviewer 2:

The reviewer cited a two-fold projective objective, first, to understand the role of Li_2MnO_3 in the performance of LMR-LLC cathodes and correlate the bulk structural and interfacial changes in the Li_2MnO_3 component with its performance, and second, to develop alternate multivalent cathodes, $Li_2(NiCu)O_2$ with high specific capacity. The reviewer noted that some time was also spent on the EIS behavior of the LMR-LLC cathodes, which the reviewer believed was not well connected with the objective of seeking structure versus performance correlation in the LMR-LLC cathodes. It is interesting to study Li_2MnO_3 alone during lithation/delithiation cycling to understand its behavior in the composite cathode, the reviewer agreed, but found it unclear why this material was studied in the thin-film and slurry electrolyte electrode forms. The reviewer noted that, with the low specific discharge capacities, the extent of delithiation in Li_2MnO_3 is less than in the composite cathode. Overall, the reviewer said, the approach seems feasible and consistent with the program goals.

Reviewer 3:

$Li_2Cu_xNi_{1-x}O_2$ is an interesting system, the reviewer said, and can be a candidate high-voltage and -capacity cathode material. However, the reviewer went on, initial capacity decay and oxygen evolution at less than 4.0 Volt (V) should be explained and the relationship between capacity decay and oxygen evolution should also be discussed.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer considered that the team did a good job in characterizing Li_2MnO_3 and LMR/NMC cathodes using a number of analytical tools such as EIS, Raman, and Xanes. These were done quite effectively, the results are of high quality and the authors reached careful conclusions in the reviewer's estimation. The reviewer termed the work with Li_2CuO_2 challenging but encouraging, adding that although the current data are far from promising (most of the capacity being at a low voltage), an opportunity to tailor the material in future studies has probably been opened.

Reviewer 2:

The reviewer said study $Li_2Cu_xNi_{1-x}O_2$ cathode's electrochemical stability and capacity retention.

Reviewer 3:

The reviewer noted some interesting and useful observations on the delithiation behavior of Li_2MnO_3. The formation of MnO_2 at high voltages is expected, the reviewer said, but asked if there was any gas (oxygen) evolution along with it at these high potentials (4.7 V). The reviewer was unclear as to why this material was studied in thin-film form as well as slurry electrode form. In either case, delihiation seems to be equally difficult, making it difficult to take cathode to deep delithiation. Likewise, the reviewer was unsure what to make of the EIS behavior, which is expected to be a function of voltage or degree of delithiation. The preliminary performance data on $Li_2Cu_xNi_{1-x}O_2$ are encouraging, the reviewer said but there is still considerable oxygen evolution (favored thermodynamically) at these potentials. The reviewer saw no clear strategy presented on mitigating this oxygen evolution and wondered if cation substitution would alter the charge potential. The cyclic stability of $Li_2Cu_xNi_{1-x}O_2$ has been improved, but the voltage profile is still not attractive, with low potentials for the second Li. Finally, the reviewer reiterated that overall progress is good and directed toward the DOE goals.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

An excellent collaborative team, the reviewer said.

Reviewer 2:

There are good ongoing collaborations with the other DOE laboratories and external university, and U.S. Department of Defense (DOD) collaborators, in the reviewer's opinion.

Reviewer 3:

The PI has developed collaborations with LBNL, Brookhaven National Laboratory, ANL, National Accelerator Lab and the Ford Motor Company, the reviewer observed.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

It is important to stabilize $Li_2Cu_xNi_{1-x}O_2$ structure at high voltages, the reviewer said.

Reviewer 2:

The reviewer noted that the project is ending this year, with the focus on the high-capacity 2-Li copper (Cu)-Ni oxides, specifically to reduce particle size to improve kinetics, eliminate impurities and improve the stability through cation substitution. Finally, these cathodes will be studied to determine the stability of redox active Cu and Ni using in situ synchrotron XAS and diffraction. These plans, the reviewer said, are consistent with overall goals of the Applied Battery Research (ABR) program.

Reviewer 3:

Noting that the project team now wants to work with this 2-e Li_2CuO_2 cathode, the reviewer suggested that the material be explored exhaustively without the distraction of other, ancillary projects. The PI, in the reviewer's estimation, is well experienced to explore its full potential. The reviewer, however, expressed a concern about this material, asking if there is any dissolution a la spinel and inquiring about its high-temperature behavior.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The project does support DOE goals, the reviewer said, because high-voltage cathodes are critical for developing high-energy-density and lower-cost batteries.

Reviewer 2:

The reviewer noted that high specific energy, long cycle life and low cost are the performance drivers for Li-ion batteries in electric vehicles and that LMR-LLC cathode materials are promising due to their high capacities at high voltages, and possibly their low cost from the high Mn contents. However, their performance degradation upon cycling, both in capacity and voltage, are impediments to their use in Li-ion cells. This project, the reviewer observed, is aimed at understanding and mitigating these failure modes and is developing a high-capacity cathode, $Li_2(CuNi)O_2$ for high-energy Li-ion cells.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The funding level seems right, the reviewer said.

Reviewer 2:

The resources are adequate for the scope of the project, in the view of this reviewer.

PHEV and EV Battery Performance and Cost Assessment: Kevin Gallagher (Argonne National Laboratory) - es111

Presenter

Kevin Gallagher, Argonne National Laboratory.

Reviewer Sample Size

A total of five reviewers evaluated this project.

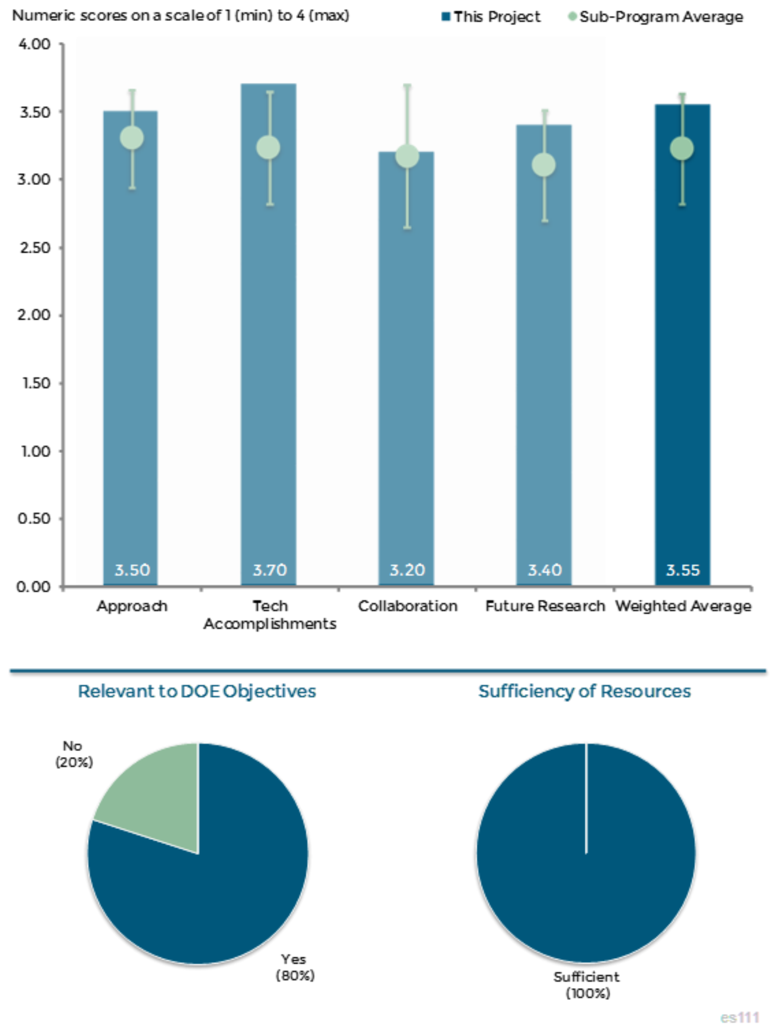


Figure 2-13 PHEV and EV Battery Performance and Cost Assessment: Kevin Gallagher (Argonne National Laboratory) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This, the reviewer said, is a well-focused project to develop design and simulation capabilities for assessing performance and cost of Li-ion batteries.

Reviewer 2:

The reviewer praised this as a very dynamic effort to make BatPaC a useful tool and predicted that it will continue to be so for years as new designs and materials are identified. The BatPaC model development work contributes greatly to the improvement in performance and cost prediction of known battery chemistries, the reviewer said, noting that it was clear a lot of work went into the development effort for modeling both cell and – to some degree – battery pack costs. The described change in approach, in the reviewer's opinion, allows for improved results that fit actual vehicle usage. Finally, the reviewer remarked, a cost variable that should be added is that cell fabrication and pack build may be done in very different locations.

Reviewer 3:

The PI, the reviewer opined, knows the critical input needed for high reliability, cost and performance estimates.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

BatPaC has been released and used widely by the battery community, the reviewer observed.

Reviewer 2:

The team has done an excellent job, the reviewer said, in providing guidance and recommendations for electrode loadings, thicknesses/transport limitations for EV targets, although the reviewer could not recall having seen the same calculations for PHEVs. This is very useful guidance for battery developers and highly relevant, the reviewer continued, but a high-level summary of assumptions, a short note on the models' limitation might be a very useful aid to better comprehension. The reviewer was left with several questions; first, was the charging situation considered in continuous power demand calculations, and if so, up to what rate levels. Second, how do the rapid gas discharge pathway calculations fit into this project. The reviewer noted that the assumptions for the Li/S model were missing – how much excess Li was there and what were the current collector assumptions.

Reviewer 3:

The technical accomplishments were clear in the tables presented, the reviewer noted, and the slide showing the value of the advanced cathode work and the potential cost and volume savings was very good. The significant role the anode plays in cost and volume savings was also informative and may, the reviewer speculated, drive more work on this system. The model provides directional cell development toward a Mn-rich cathode and Si/Gr composite anode as the likeliest cost winner. Additional benchmark test work will of course, identify if this is the best performance/cost winner.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

Noting that collaboration partners included cell materials developers and manufacturers, as well as battery manufacturers, regulatory groups and one of the world's largest automotive battery users, the reviewer added that this type of collaboration is needed to develop and validate the system from both technical and business perspectives.

Reviewer 2:

The partners – battery developers and producers – will be able to validate the model, the reviewer observed.

Reviewer 3:

The reviewer suggested that collaboration with significant, high-volume cell manufacturers via confidential information exchange agreements to include more real-world information could be an improvement opportunity toward a greater level of reality in output. The reviewer also suggested that this might best be accomplished by an organization outside of ANL which can assure collaborators of information protection, while allowing ANL modelers access to genericized model data.

Reviewer 4:

While collaboration has been good, the reviewer said, there are more opportunities to expand.

Reviewer 5:

The reviewer noted there was no mention of involvement by electrode manufacturers.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The proposed work is highly relevant and useful, the reviewer said, especially electrode thickness calculations, updating of cost models, energy demand calculations and fast charging studies. Because virtually all suppliers are moving toward a single cathode system, the reviewer did not recommend the study be carried out unless it was desired to validate the model using the Volt as a test case.

Reviewer 2:
The presentation, the reviewer remarked, points to a critical role that the anode plays in the volume and cost, but this effort is not clearly included in the future work, unless the blended cathode was intended to be a blended Si/Gr anode. While acknowledging the need for fast charging to facilitate extended driving range, the reviewer called for more details on how the fast charging work will be included in the BatPaC future work to assess the value of its being called out as a focal point for future work.

Reviewer 3:
The future work is well defined and will add to the usefulness of the model, according to this reviewer.

Reviewer 4:
The reviewer expressed support for looking more at sulfur.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
This project fits well within the overall DOE program, the reviewer said, as having a reliable model for performance simulation and cost assessment is very useful for tracking progress as well as benchmarking and projecting various battery systems.

Reviewer 2:
The BacPaC model helps identify ways a cell manufacturer can realize a meaningful cell cost reduction, the reviewer noted, and because cell cost is at least 50% of an automotive battery cost, it represents one of the biggest hurdles for adoption of this technology as a viable alternative to the internal combustion engine (ICE). Consequently, any system that allows a meaningful cell cost reduction supports the DOE objective to reduce petroleum usage, the reviewer concluded.

Reviewer 3:
The model will lead to optimized decision making on designing and building batteries, the reviewer predicted.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The resources provided should be sufficient to meet the stated milestones, in the reviewer's opinion.

Reviewer 2:
The ANL modelers and the industry support will be sufficient to achieve the milestones, the reviewer agreed.

Open Architecture Software for CAEBAT: John Turner (Oak Ridge National Laboratory) - es121

Presenter

John Turner, Oak Ridge National Laboratory.

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

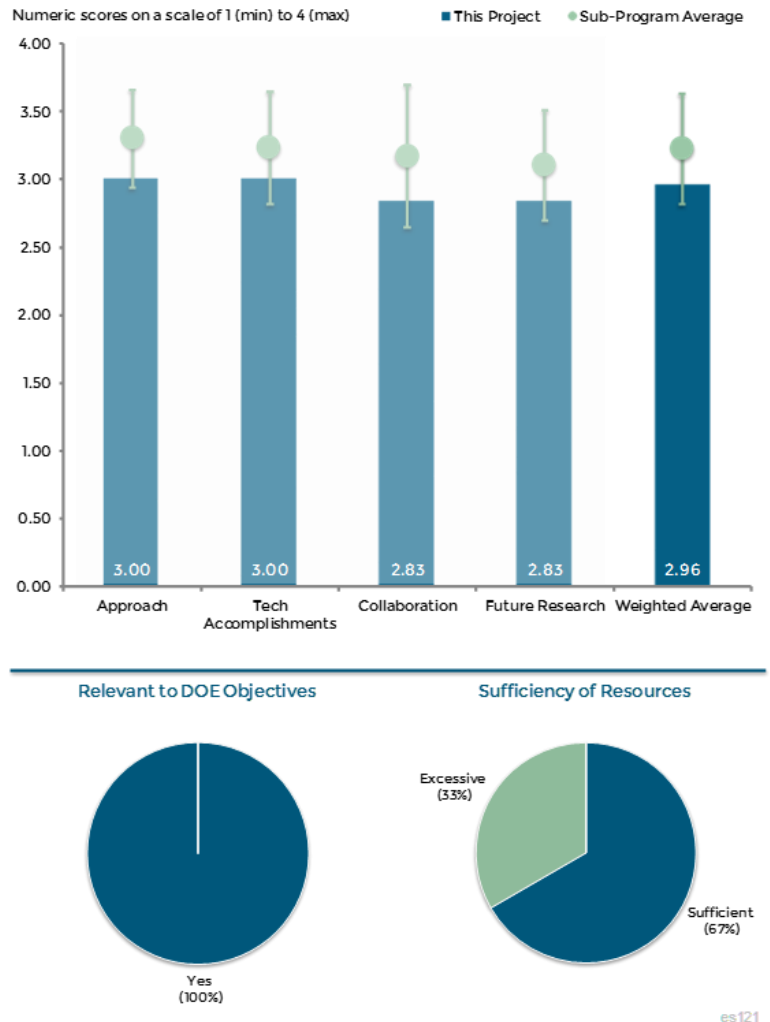


Figure 2-14 Open Architecture Software for CAEBAT: John Turner (Oak Ridge National Laboratory) - Electrochemical Energy Storage

Reviewer 1:

This project, the reviewer said, addressed the barrier that there is no common framework for integrating battery modeling efforts and standards for battery modeling, and is well coordinated with other CAEBAT projects.

Reviewer 2:

Approach 1 is summarized schematically in Slide 6: CAEBAT [Computer-aided engineering of batteries] Open Architecture Software Vision - a Virtual Test Bed, the reviewer noted, adding that it was unclear whether the validation piece falls under the scope of this project. Even if some of the contributions are from external sources (test results from ABR, Batteries for Advanced Transportation Technologies [BATT] and industry), the reviewer believed it would be useful to show more examples of various model outputs agreeing with experimentally generated data. Given the complexity of the work and the broad suite of integrated components, it is difficult to generate a very simple overall statement of objectives and work flow, the reviewer acknowledged, but this would be useful. Also, it was not entirely clear to the reviewer which, if any, of the modules were created under the program and which were merely integrated into the open architecture software (OAS). The decision to include four software suites (from various commercial partners) enhanced the flexibility and lowered overall risk, the reviewer concluded.

Reviewer 3:

The objective of this project was somewhat unclear to the reviewer. It was evident that this platform allows the combination of commercial and public software through a standard interface; however, the specific type of problem that motivates this synergy needed clarification, in the reviewer’s opinion, or at least the provision of a matrix of the range of physical problems that may be addressed using this technology.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

To the reviewer, the ambitious technical goals appeared largely complete and that a notable endorsement of the value of the work was visible in the Virtual Integrated Battery Environment (VIBE) download statistics, illustrating the tool's significance to industry and academia. File-based coupling of electrochemistry, transport, and electrical and mechanical stress models extends the usefulness to many very relevant problems such as thermal management and internal short response prediction, and the flexibility to accommodate various form factors and array configurations is also useful and essential, in the reviewer's estimation.

Reviewer 2:

It was unclear to this reviewer how the types of example problems being solved are distinguished from those that can be solved with existing commercial, multiphysics software (e.g., COMSOL). The reviewer inquired about the capability that is being added here, and the impact, with this platform that exceeds what is commercially available. A clearer benchmark of existing commercial platforms and deficiencies would better support the research.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

Extensive coordination and collaboration efforts were critical to success for this work, given its integrative nature, and the diversity of the participants – academia, industry and other DOE partners – was clearly shown, the reviewer said. The reviewer observed that the multi-faceted engagement efforts and the significant publications and presentations on the subject were likely helpful in giving the work some visibility, as illustrated by the many users. It was also clear to the reviewer that there is a structured approach to getting and incorporating feedback from initial users at every level (including creation of users' mailing list), and that the intent is to continue incorporating revisions based on community feedback. The reviewer asked if there is a central introductory overview online designed to communicate the scope of the capabilities and vision written not for the end-user, but for the researcher and industry member who would have a use for the results. This might accelerate dissemination, in the reviewer's view.

Reviewer 2:

The reviewer would like to know what the role is of the GM-ANSYS and CD-Adapco teams in this project and how these teams have been integrated into the research effort.

Reviewer 3:

The reviewer recommended that the project team double check to see if all the models developed in other CAEBAT projects are compatible with VIBE/OAS.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The work is largely complete, the reviewer noted, but in the longer term, adding new features does not provide a lot of information. Elaboration in this area would be useful to understand which technical areas will be pursued next. It would also be useful to better understand the comment (Slide 24) "compatible with at least some components of CAEBAT." The reviewer asked which components and what is the reason for the incompatibility of others. The reviewer wondered if this is a problem to be solved or is it of little importance.

Reviewer 2:
The PIs should clarify the advantages of this platform per the comments in the Technical Accomplishments and Progress section, the reviewer said.

Reviewer 3:
The reviewer wondered if OAS can interact with LS-Dyna and Fluent-API.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
Validated and reliable models are invaluable in accelerating development and shortening time to market through efficient and less costly optimization, the reviewer pointed out. Thus, having an OAS tool available not only to industry, which may have similar tools in some cases, but for the smaller and growing entities which may have great ideas but rely heavily on modeling, will encourage innovation and growth.

Reviewer 2:
This project is focused on advanced simulation tools for electrified vehicles, which is a key enabling technology for petroleum displacement, the reviewer said.

Reviewer 3:
The reviewer considered that this is an integral part of developing software tools to design and model batteries.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
Given the technical complexity, the multi-partner, multi-platform approach, the resources did not seem excessive to this reviewer, who also noted that tremendous resources are required for broad-suite, comprehensive testing, so if this tool can allow test matrices to be reduced, its value will be well justified.

Reviewer 2:
These resources may be excessive if the impact of the research is not more clearly defined, the reviewer said.

Composite Electrolytes to Stabilize Metallic Lithium Anodes: Nancy Dudney (Oak Ridge National Laboratory) - es182

Presenter

Nancy Dudney, Oak Ridge National Laboratory.

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

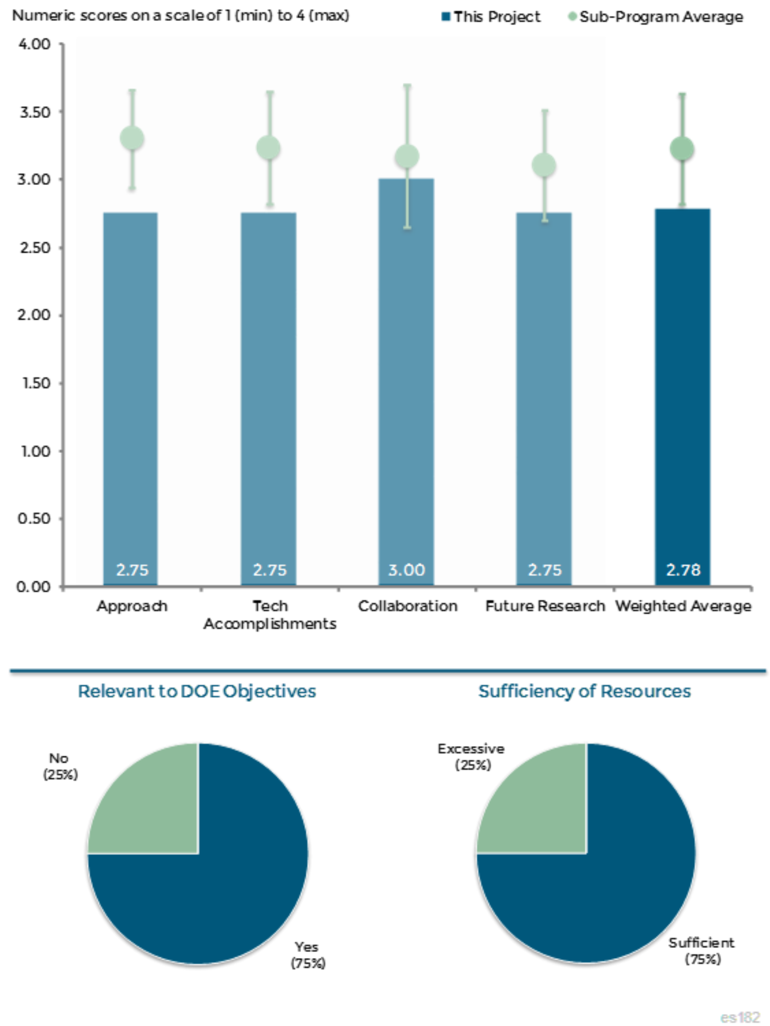


Figure 2-15 Composite Electrolytes to Stabilize Metallic Lithium Anodes: Nancy Dudney (Oak Ridge National Laboratory) - Electrochemical Energy Storage

Reviewer 1:

Noting that one of the main approaches, namely, “use theory and simulation to explore mechanical stability” has apparently been postponed because of the variability in the measured ionic conductivity caused by the presence of impurities, the reviewer remarked that it may be helpful to know whether these impurities would also cause problems with mechanical properties, and thus provide deeper insights into the role of impurities at interfaces.

Reviewer 2:

The promise of a solid electrolyte for Li batteries is high, the reviewer said, and the initial technical approach was interesting, but this technical plan, in the reviewer’s opinion, got waylaid. Because it has always been understood that processing and manufacturing would be among the larger issues, the reviewer found it unsurprising that this has been the sticking point in this research. However, the shift in focus appeared to the reviewer to be quite academic. It is important to keep in mind, the reviewer asserted, that the intention has always been to scale this up for manufacturing. Exposure is quite a nebulous term, especially on a high-speed manufacturing line; the impact of exposure time was never discussed, the reviewer said, and is likely to be the key point in commercialization. Additionally, it needs to be clear that the liquid electrolyte is not adversely impacting SEI formation. A clear focus must be maintained on the commercial applicability and reproducibility of this environment to ensure that this research has its intended impact, the reviewer concluded.

Reviewer 3:

Noting excellent attention to detail and extra steps taken to separate differences in experimental set-ups, the reviewer offered that it might be very beneficial to establish a baseline and the SOP to detect and characterize the outlier results more rapidly; this in turn might open an opportunity for the new inventions.

Reviewer 4:

The reviewer concluded that this project appeared to be a mess of uncontrolled process variations. While some of the outcomes may be of interest, it seems that it would be necessary to get to a baseline performance level where the variation is removed is necessary in order to proceed with the introduction of controlled variations.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

It may be helpful, the reviewer suggested, to use depth profiling techniques (e.g., XPS, Auger, SIMS, Rutherford Backscattering, Elastic Recoil analysis) to determine the species present at the interface between polymer- and ceramic-electrolyte interfaces to resolve the observation that "subtle differences in composite processing have large impacts on the bulk conductivity." These depth profiling techniques have been used successfully in the development of doping of the p-n junctions in the microelectronics industry, the reviewer added. It may also be helpful to measure ionic conductivity across the layered polymer-ceramic electrolyte interface as a function of applied stress to help understand whether interface contact area plays a role (e.g., contact area at the interface increases with increasing normal load).

Reviewer 2:

The reviewer said introduction of the statistical tools and standards might further accelerate the progress.

Reviewer 3:

To this point, the work does not appear to be reproducible in another lab or even after the glove box was changed for maintenance, the reviewer observed, adding that it is important to know to what degree the environment is saturated. While this study is interesting, the reviewer went on, it still appears the Ohara ceramic is the best. While this may be true for bulk conductivity, the effective conductivity including the interface may be limiting. The reviewer proposed that it might be best to showcase the improvement this research is providing to show progress toward the original technical goals and it needs to be clearer to what degree. A fair bit of this work seemed to the reviewer to be better suited to the DOE Office of Basic Energy Sciences (BES) as opposed to VTO. The reviewer stressed that greater focus should be applied to understanding the interface.

Reviewer 4:

The reviewer believed this project possibly needs to start from zero.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer was pleased to note not only outstanding collaboration efforts, but coordination of the materials studied.

Reviewer 2:

Noting an appropriate collaboration of ceramic electrolyte partners, the reviewer believed that engagement of a commercialization partner would help make this research more readily applicable to the industrial process.

Reviewer 3:

The reviewer was not quite able to determine where collaborators are contributing.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The research project is very challenging, the reviewer assessed, but the PI understands the critical issues and has a well-thought-out plan to attack them.

Reviewer 2:

The reviewer suggested it may be helpful to use depth profiling techniques (e.g., XPS, Auger, SIMS, Rutherford Backscattering, Elastic Recoil analysis) to determine the species present at the interface between polymer- and ceramic-electrolyte interfaces to resolve the observation that “subtle differences in composite processing have large impacts on the bulk conductivity.” These depth profiling techniques have been used successfully in the development of doping of the p-n junctions in the microelectronics industry, the reviewer added. It may also be helpful to measure ionic conductivity across the layered polymer-ceramic electrolyte interface as a function of applied stress to help understand whether interface contact area plays a role (e.g., contact area at the interface increases with increasing normal load). The reviewer also suggested that it may be helpful to predict theoretically what species present at the interface would be helpful to ionic transport.

Reviewer 3:

The reviewer termed the Proposed Future Work section sparse, saying it would be best to refocus the last year of this project to reflect some of the critiques of the work.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The development of higher energy-density, longer cycle-life batteries with improved safety profiles would accelerate the electrification of the transportation sector, the reviewer predicted.

Reviewer 2:

The success of this project will enable battery systems that can address DOE performance and cost targets, the reviewer said.

Reviewer 3:

Even were this a feasible, well-performing program, the reviewer said, adding that it currently is not, the approach is questionable. The reviewer expressed remaining concerns about the viability of solid Li in a large-format cell that might be subjected to a physical breach by outside forces. The reviewer clarified that expression of this concern was not to suggest that the performance of the solid Li system is unattractive or even unattainable, merely that the reviewer worried about whether it can ever truly be safe from external issues.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

An excellent team and access to the characterization tools, was the reviewer’s comment.

Reviewer 2:

The reviewer noted that the budget presented was for FY 2013 and FY 2014. The reviewer further asserted that no comment can be made, as this appears to be sloppy preparation.

In-Situ Solvothermal Synthesis of Novel High-Capacity Cathodes: Feng Wang (Brookhaven National Laboratory) - es183

Presenter

Feng Wang, Brookhaven National Laboratory.

Reviewer Sample Size

A total of three reviewers evaluated this project.

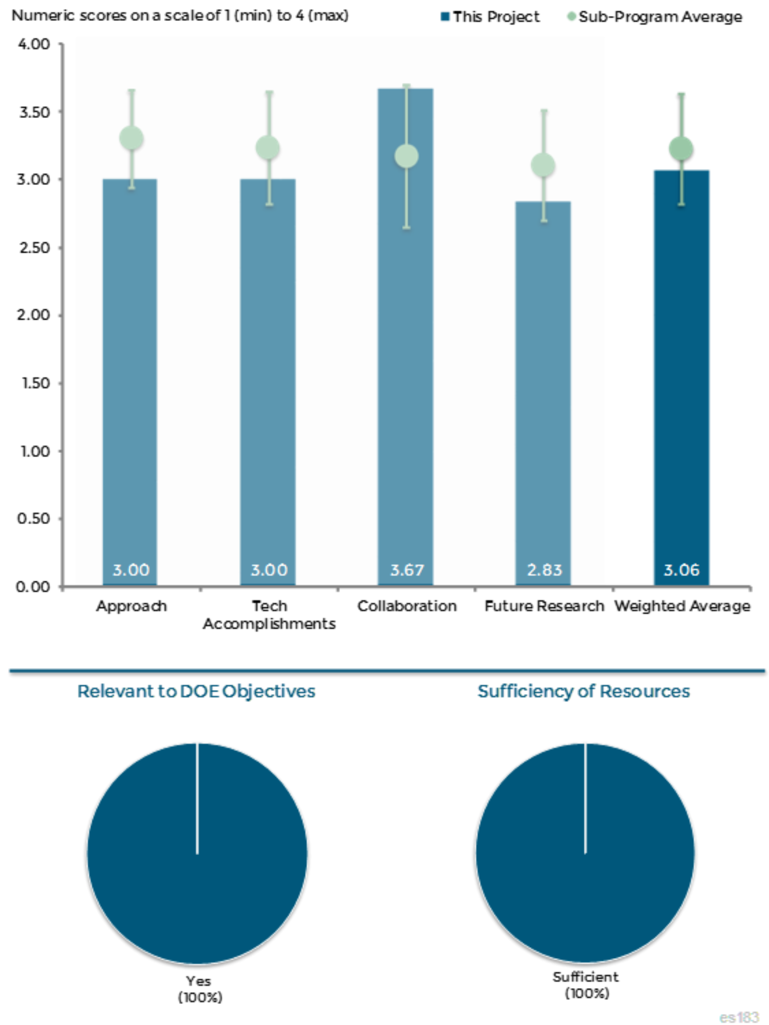


Figure 2-16 In-Situ Solvothermal Synthesis of Novel High-Capacity Cathodes: Feng Wang (Brookhaven National Laboratory) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

Describing the objective as being to investigate thermodynamic and growth kinetics using various in-situ methods, the reviewer predicted that in-situ study of batteries will significantly and directly help to understand the structure and different phases/compositions.

Reviewer 2:

The reviewer described the project objective as being to develop high-capacity cathodes, including polyanionic cathodes ($LiVPO_4X$) with multi-valent redox capability for high capacity, with high voltage (PO_4) and open framework for high Li+ mobility. Also, a small effort is placed on Cu-V-oxygen (O) and Cu-Fe-fluorine (F) cathodes of high capacity. For a proper assessment of the new materials, the reviewer cautioned, it is important that the synthesis method results in phase-pure materials and allows good control of stoichiometry and morphology. The approach is based on utilizing the in-situ solvo-thermal synthesis developed in this project which enables controlled synthesis of cathodes of desired phase and properties and is based on a combination of specialized in-situ reactors and time–resolved XRD probing for quantitative understanding of structure/phases during syntheses as well as during further lithiation-delithiation cycling. The technique appears to be quite useful in the development of new materials, the reviewer eventually observed. Three different families of cathode were explored; some of them displayed high capacities, but only at low potentials. The result, the reviewer concluded, is that there is not much improvement in the energy densities compared to the conventional cathode materials.

Reviewer 3:

Aside from the in-situ work in reactors, the reviewer said, the other topics are either low-impact or variations of work previously out. The reviewer did not consider it a negative, but also noted some overlap with work done under project es051.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

Good progress has been made, the reviewer noted, toward developing the solvo-thermal and ion exchange syntheses processes for three different cathodes with in-situ determination of phase purity and composition, to wit, $Li_3V_2(PO_4)_3$ nanocrystals of high power density, $Li(Na)PO_5F$ with high Li content and Cu-V-O and $CuFeF_2$ cathodes of high capacity. The method appears to be quite useful to explore new cathode materials, in the reviewer's estimation. Of the three cathode materials studied, both $Li_3V_2(PO_4)_3$ and $Li_xNa_{1.5-x}VPO_5F_{0.5}$ have low specific capacities, while the copper vanadates and fluorites have lower discharge voltages to make them appealing for the high-energy Li-ion cells. Overall, these studies are interesting from an academic perspective, the reviewer believed, but do not add much value from the application perspective. The reviewer recommended focusing more on materials that can offer improved energy densities compared to the conventional cathodes to take advantage of this method and to make these studies relevant to VTO.

Reviewer 2:

The team's work on micro-reactors and in-situ monitoring of reaction pathways is certainly very interesting and useful and the team has done a good job in characterizing the materials in the course of synthesis, the reviewer stated, expressing the belief that this was the strength of the work. The reviewer was left with one question, however, namely, how have these studies helped the authors redesign their synthetic procedures. Other aspects of the work, however, such as ion-exchange, lithium iron phosphate (LFP), Cu-V-O or Cu-Fe-F are low-impact studies, the reviewer said, the first being impractical, the second mature and the third offering too little capacity at high voltage.

Reviewer 3:

Both vanadate and fluorite compounds have such low potentials that they are not practically useful, in the reviewer's opinion.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted collaboration with a lot of relevant laboratories.

Reviewer 2:

This is a good collaborative project, the reviewer said, involving interactions with several laboratories and universities.

Reviewer 3:

PI has developed collaborations with many researchers at a number of national laboratories and universities, the reviewer observed.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer is unsure which new high-capacity Ni-Mn cathodes the authors are planning to synthesize. The reviewer believed that if the authors leverage the techniques they have developed so far then there is certainly a lot of good value in the future work. On the polyanionic front, the reviewer recommended that the various researchers reach some type of understanding to prevent overlap. This reviewer said that fluorites and vanadates have low capacity at high voltages and expressed doubt that it is worthwhile pursuing them.

Reviewer 2:

The future plans are to continue development of polyanionic cathodes, ($Li(Na)VPO_5F_x$), to explore polyanion-type ternary and quaternary Li-V phosphate cathodes, i.e., Li-V-PO_4 cathodes, to investigate the new α-CuVO cathodes further and to develop new, high-capacity Ni-Mn-based oxide cathode (both layered and spinel). The solvo-thermal synthesis with in-situ analysis to ensure phase purity and composition enables such exploratory work and the reviewer urged this project continue to identify and screen new cathode materials that have the potential to provide higher specific energies compared to state-of-the-art cathode materials.

Reviewer 3:

It is proposed to apply existing in-situ methods to different cathode materials, the reviewer observed, adding that this is not much different from previous work.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The work is certainly relevant, the reviewer stated, especially the reactor work/in-situ monitoring studies, which are insightful and instructive.

Reviewer 2:

Low specific energies and high costs are the limitations of current Li-ion batteries for EV applications. While several engineering improvements have contributed to a marginal increase in specific energy recently, the reviewer noted, new, high-specific-energy materials are desired to fill the gap. State-of-the-art cathode materials provide capacities of only about160 mAh/g, about half of capacities possible from C anodes. The present project, the reviewer concluded, is aimed at developing new cathode materials with much higher specific capacity/energy.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The resources are adequate for the scope of the project, according to this reviewer.

Lithium Bearing Mixed Polyanion Glasses as Cathode Materials: Andrew Kercher (Oak Ridge National Laboratory) - es184

Presenter

Nancy Dudney, Oak Ridge National Laboratory.

Reviewer Sample Size

A total of three reviewers evaluated this project.

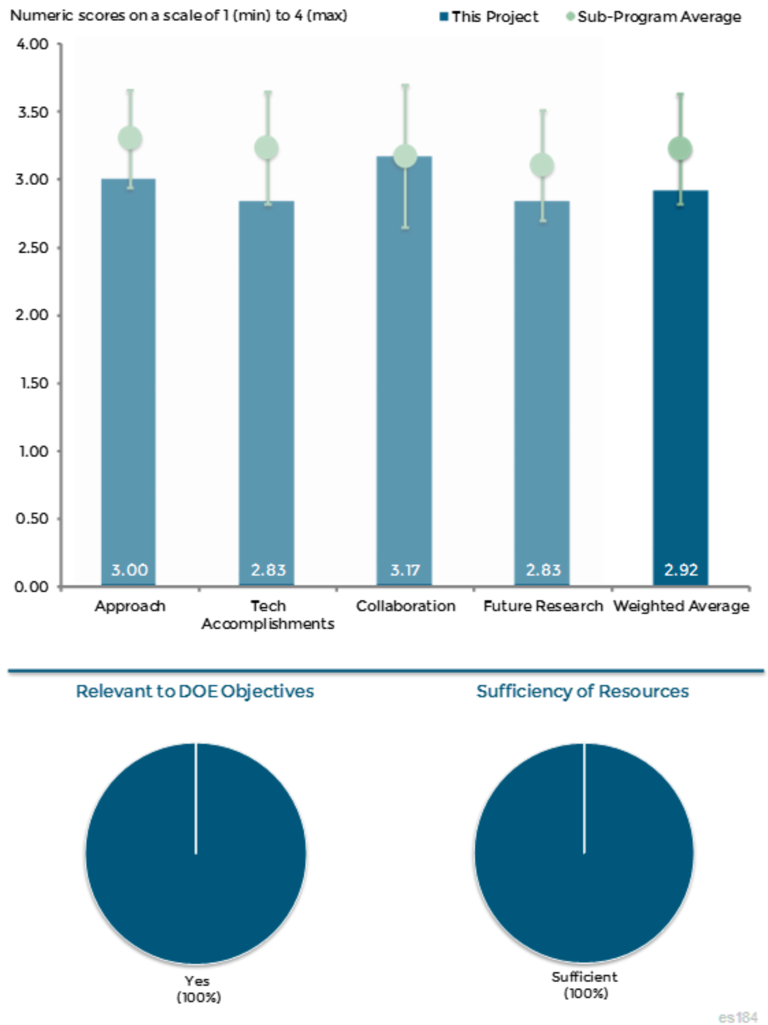


Figure 2-17 Lithium Bearing Mixed Polyanion Glasses as Cathode Materials: Andrew Kercher (Oak Ridge National Laboratory) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

Polyanion substitution increased the specific capacity and electronic conductivity, the reviewer observed.

Reviewer 2:

This was a high-risk, high-payoff project, the reviewer stated, noting that the project team had tried various avenues to improve upon several intrinsic limitations of glassy materials for use as high-energy electrode materials.

Reviewer 3:

The premise for this project is that the mixed polyanion glasses may alleviate the problems of poor conductivity and irreversible phase transitions posed by traditional crystalline polyanion cathodes of theoretically high capacities, the reviewer stated, offering the examples of $LiMnBO_3$, $LiCoBO_3$ and Li_2CoSiO_4. The objective of the work, the reviewer went on, is to synthesize and mix polyanion glasses in the phosphate family containing a variety of transition metal cations to have specific energies exceeding that of $LiFePO_4$, specifically V-substituted Fe phosphate glasses such as $Fe_4(P_2O_7)_3$ with 30-50% vanadate, which showed improved specific capacity and rate performance. To achieve high capacities, the reviewer said, conversion reactions may be used in lieu of or in addition to insertion reactions. However, conversion reactions in crystalline form have considerable hysteresis and poor reversibility. In glassy form however, the conversion reactions (charge) may be easier (for recharge), in principle. High capacities have been achieved with some of the mixed polyanions glasses as expected, but the capacity fade is still high. Nonetheless, the reviewer concluded, the approach looks promising and the project is well integrated with the other materials-based efforts.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

Reasonably good progress, in the reviewer's estimation, has been made in synthesizing and evaluating the V-substituted, Fe-phosphate cathodes in glass state. High capacities have been realized with Fe-pyrophosphate and in Cu or Co meta-phosphate glass with 50% vanadate substitution. However, fade rate during cycling is rather high, especially with the conversion reactions. Moreover, the potentials for the second reaction are rather low, but may possibly be improved with suitable substitutions/dopants. A good comparison, in the reviewer's view, will be the specific energy of the cathodes, rather than their specific capacities. It was also shown that the phosphate glasses with vanadate or molybdate have similar total specific capacity and cycle performance and molybdate will avoid the environmental concerns with V. Overall, the mixed polyanion approach looks appealing, the reviewer said, but the benefits from these mixed polyanion glass compounds are not yet significant compared to the crystalline analogs or other cathode options being explored under VTO.

Reviewer 2:

The reviewer noted that the authors have developed several new compounds that clearly do not exhibit any potential for use as high-energy cathodes because discharge voltages are mostly below 2 V. In fact, the reviewer said, they have features similar to those of anodes and also undergo rapid fade.

Reviewer 3:

For the developed glass cathode, most capacity was contributed at voltages less than 2.0 V, a level not practically useful, in the opinion of this reviewer.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

There are good ongoing collaborations with MIT and Northwestern University on the XANES characterization and modeling of these cathode materials, respectively, said the reviewer.

Reviewer 2:

Collaborations have been developed with Brookhaven National Laboratory and MIT, the reviewer noted.

Reviewer 3:

The reviewer would have welcomed more collaborative work, especially from the characterization point of view.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The proposed future research, the reviewer summarized, is to focus on the mixed polyanion glass cathodes with emphasis on increasing the free volume and conductivity for the multi-valent insertion reactions and improve the capacity fade, discharge voltage and the hysteresis for the conversion reactions. Also, the future plans are to extend these studies to non-phosphate and non-traditional glasses. Overall, these proposed studies are logical and provide alternate development pathways for the development of high-energy cathode materials to mitigate the performance limitations observed in the crystalline materials, in the reviewer's opinion.

Reviewer 2:

The reviewer was unsure any of the future tasks proposed will lead to any result substantially better than has been observed thus far. It may be, the reviewer speculated, that use of non-traditional glass-formers, of which the reviewer wished the team had given some examples, might suggest a different direction to the investigation, because none of the traditional glass-formers yielded any interesting results. The reviewer raised a question concerning the effect of nanoparticles. Given the low probability of success with these materials, the reviewer wondered whether the project team might rethink its future plans and develop an aggressive, out-of-the-box idea for the remainder of the program.

Reviewer 3:

The reviewer cited a lack of strategy for improving cathode voltage and conductivity

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

It is a high-risk project that, if successful, might be relevant, the reviewer thought.

Reviewer 2:

The limited range and high cost of Li-ion batteries are serious impediments to their use in electric vehicles. High-energy-density electrode materials will result in improved specific energy for Li-ion cells, increased range for the vehicle and reduced overall battery cost. State-of-the-art cathode materials provide capacities of only around 160 mAh/g, about half the capacities possible from the C anodes. Thus, the reviewer concluded, there is a need to develop new cathode materials of higher specific capacities, possibly with multi-electron redox processes, as is being addressed in this project.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

Funding level seems right, the reviewer said.

Reviewer 2:

The resources are adequate for the scope of the project, in the reviewer’s opinion.

Significant Enhancement of Computational Efficiency in Nonlinear Multiscale Battery Model for Computer-Aided Engineering: Gi-Heon Kim (National Renewable Energy Laboratory) - es197

Presenter

Gi-Heon Kim, National Renewable Energy Laboratory.

Reviewer Sample Size

A total of three reviewers evaluated this project.

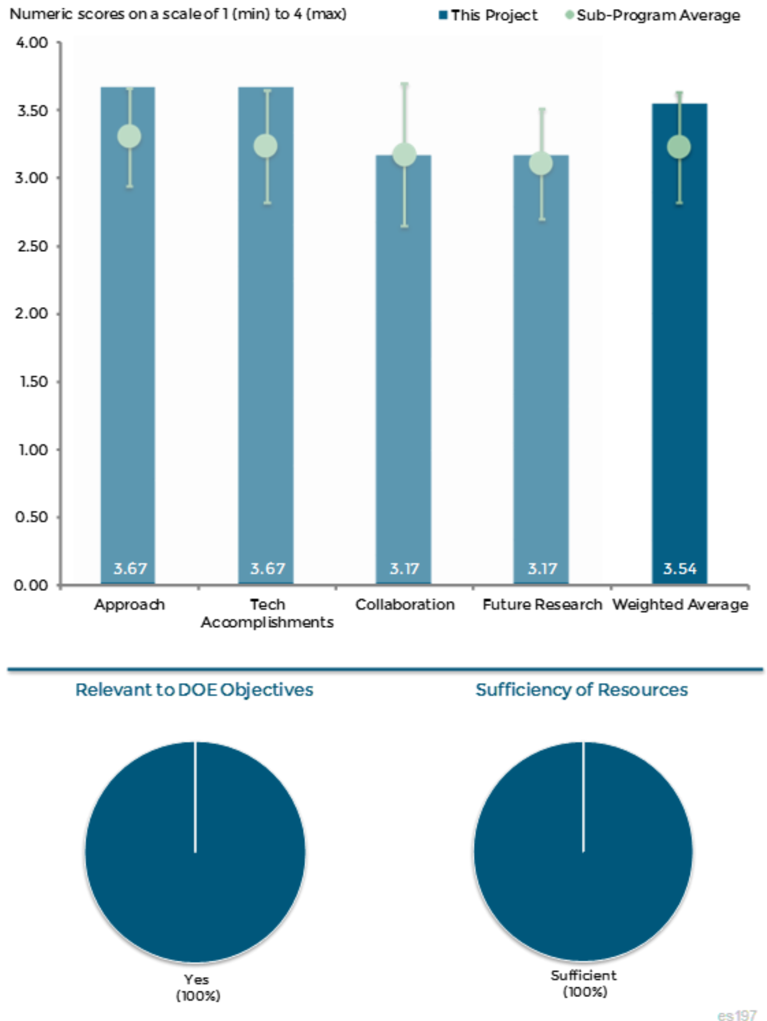


Figure 2-18 Significant Enhancement of Computational Efficiency in Nonlinear Multiscale Battery Model for Computer-Aided Engineering: Gi-Heon Kim (National Renewable Energy Laboratory) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This an excellent project, the reviewer stated, addressing computational efficiency issues experienced in CAEBAT.

Reviewer 2:

The reviewer termed this a complex task that the team had approached with a focus on imparting maximum relevance to industry and general users and noted the segregation by time-scale as representing an elegant approach, with the great increase in computational speed providing evidence of the effectiveness of the strategy taken. Equally impressive to the reviewer was the fact that the increased speed came with no significant reduction in the accuracy and integrity of the results versus those achievable with much greater computing time.

Reviewer 3:

The project targets and approach appeared to the reviewer to be relatively clear.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

Noting the target of achieving a 100 times faster computational speed had been defined and attained, and in some scenarios exceeded, the reviewer stated that this greatly enhanced the usefulness of the GH-MSMD. Code implementation in C++ and MATLAB, the reviewer continued, further strengthens the tool applicability. Integrating of the National Renewable Energy Laboratory’s (NREL) custom electrode domain model (EDM) modules for electrochemistry, abuse reaction kinetics and ISC into ANSYS Fluent is a significant accomplishment, in the reviewer's estimation. The reviewer believed there is a significant opportunity to leverage partners from industry, ANSYS and other national laboratories with fabrication capability to conduct more validation work to address the challenging topics of ISC, fast charge, etc.

Reviewer 2:

To the reviewer, it appeared that the investigators had met their target in terms of the speed-up of the simulation process. One moderate concern the reviewer expressed concerned the generality of the method and how well it may be practically adopted in industry.

Reviewer 3:

The reviewer wondered if this model had been verified in OAS developed by ORNL.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The change in course from a direct University Partner (UP) to the UP working through ANSYS was not a negative one, in the reviewer's opinion, and possibly conferred some advantages. It was not clear to the reviewer what the status and plans for incorporation into ANSYS CAEBAT framework and ORNL OAS were. This, the reviewer said, was listed in 2014 as future work but was not shown this year under future work. The reviewer believed it would be helpful to understand where this fits in the larger scheme of things, as there are areas of overlapping research within DOE, some of which are certainly intentional.

Reviewer 2:

It seemed to this reviewer that the collaborative aspect of the research is moving forward with ANSYS. The reviewer expressed the hope that this will address the earlier comment made in the Technical Accomplishments and Progress section.

Reviewer 3:

The reviewer expressed a desire to see collaborations with vehicle and/or battery original equipment manufacturers (OEMs) on the pack-level model efficiency improvement.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

Extension of the time domain approach to development of a frequency domain GH-MSMD counterpart will be a challenging undertaking, but if successful will further broaden the applicability of the model to a more diverse range of engineering problems.

GH-MSMD is not intuitively understandable (unlike the original MSMD), but NREL is cognizant of this and is actively seeking to summarize, publicize and disseminate the features of the tool to encourage broad interest and usage.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer described practical and commercially available tools for advanced simulation of battery technologies as key enablers for future, more-electrified vehicles.

Reviewer 2:

This tool promised to be an elegant and user-friendly tool that will have broad use in industry and academia to advance challenging engineering problems in a diverse range of areas, the reviewer predicted, and its contribution to optimized material, electrode, cell and pack design may help bring down the cost of battery technology. The tool will particularly benefit those users without their own capability in this area, the reviewer added. The ability to address problems spanning multiple engineering domains (fault evolution, thermal management, aging, etc.) is valuable, the reviewer stated, and the availability of a fast and robust tool can further support screening and assessment of new materials and battery designs.

Reviewer 3:

This project targets the computational efficiency improvement to promote CAEBAT employment, the reviewer said.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

Resources are suitable for the project scope, the reviewer reiterated, while encouraging greater leverage of DOE partners for more hardware validation.

Mechanistic Modeling Framework for Predicting Extreme Battery Response: Coupled Hierarchical Models for Thermal, Mechanical, Electrical and (Electro)Chemical Processes: Harry Moffat (Sandia National Laboratories) - es198

Presenter

Harry Moffat, Sandia National Laboratories.

Reviewer Sample Size

A total of three reviewers evaluated this project.

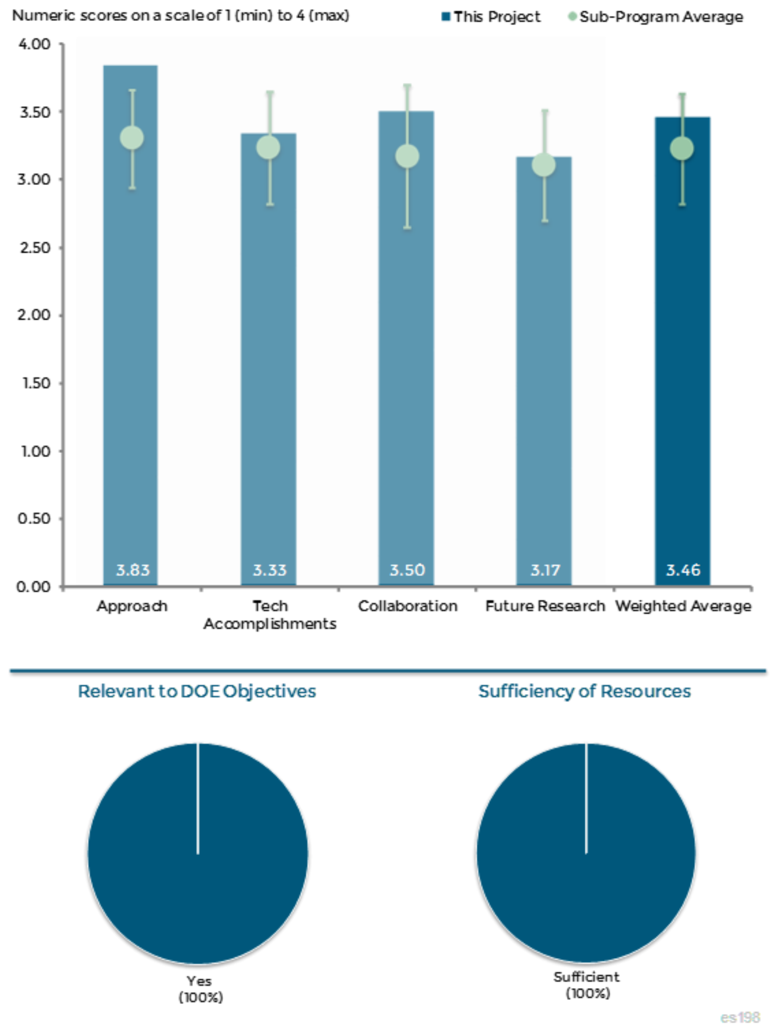


Figure 2-19 Mechanistic Modeling Framework for Predicting Extreme Battery Response: Coupled Hierarchical Models for Thermal, Mechanical, Electrical and (Electro)Chemical Processes: Harry Moffat (Sandia National Laboratories) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The strategy of integrating C++ open-source framework (with its multi-physics models) into ORNL CAEBAT open architecture is worthwhile and of value, the reviewer stated, as the project undertakes to advance the sophistication of modeling's use in particularly complex aspects of various abuse conditions, such as the role of interfaces and surface phases, cell pressurization, porosity changes and geometrical complexity of the cell microstructure. To assist with tackling this challenging array of problems, the reviewer observed, the project leverages expertise from a diverse team of collaborators: Sandia National Laboratories (SNL), ORNL, Colorado School of Mines, Duracell and other groups, and is also facilitated by an open source github site.

Reviewer 2:

The approach seemed appropriate to the reviewer, in view of the final goal being an open source platform.

Reviewer 3:

The modeling effort is capable of predicting the battery effects of several abuse conditions, something that is needed in the vehicle and battery industries for battery design, the reviewer said.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

It appeared to the reviewer that the technical accomplishments are generally on track.

Reviewer 2:

The project team has introduced an open-source multi-physics battery simulator (cantrilbat.github.com) for mechanism development, and integrated the model into the CAEBAT architecture, duplicating existing capability with Cantera/1D electrode with added functionality (e.g., new transport coefficient algorithms for organic solvent salts), satisfying the go/no go gate. The reviewer summarized that Total Enthalpy Formulation introduces the capability of handling multiple phases and multi-physics terms (e.g., solid mechanics, partial saturation) that have previously been unavailable to the battery community. The result is a model offering numerous advantages over spherical models. The reviewer was left with several questions, however, including that of which chemistries have already been incorporated and which ones (thermodynamic, transport and kinetic data, etc.) are still needed. The reviewer asked is there an understanding of the computational power and processing time required for full solutions.

Reviewer 3:

The reviewer believed it was unclear if the models developed can be generic enough for both new and aged batteries and noted that the April 1, 2015 milestones seemed to have been delayed.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

Noting excellent collaboration, with a framework for soliciting more collaboration through github, the reviewer expressed the view that adding another partner with recognized experience in Li-ion mainstream battery development and production would strengthen the list further.

Reviewer 2:

The reviewer found that the role of each collaborator was clear.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

While deeming future objectives useful and valuable, the reviewer cautioned that they will certainly be extremely challenging. The reviewer expressed the hope that the processing power will be adequate to handle the increasingly complex model components and the desire for more details about plans for experimental validation with hardware.

Reviewer 2:

As a research code, this platform may be very effective, the reviewer said, but from a more applied perspective, the impact of this project may be somewhat limited.

Reviewer 3:

The reviewer wondered if the project could leverage other CAEBAT projects to reduce the time and efforts.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
This project, the reviewer said, takes the advanced state of models in this space and pushes them forward by addressing non-idealities that previous work has ignored through simplification. Adding another degree of fidelity to predict behavior under abuse conditions, once suitably validated, is an important contribution, the reviewer added, allowing much more complete and multi-parameter study than limited hardware testing where only a partial set of abuse conditions can be explored.

Reviewer 2:
Advanced simulation tools for greater insight into the safety and reliability of electrified vehicle system components represent a key enabling technology, in the reviewer's opinion.

Reviewer 3:
This effort will develop modeling tools to predict battery performance and thermal runaway, the reviewer said.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
Resources are commensurate with the scope of work being addressed, in the reviewer's estimation.

Reviewer 2:
There are sufficient resources to achieve the proposed goals as planned, the reviewer stated.

Coupling Mechanical with Electrochemical-Thermal Models Batteries under Abuse: Ahmad Pesaran (National Renewable Energy Laboratory) - es199

Presenter

Ahmad Pesaran, National Renewable Energy Laboratory.

Reviewer Sample Size

A total of three reviewers evaluated this project.

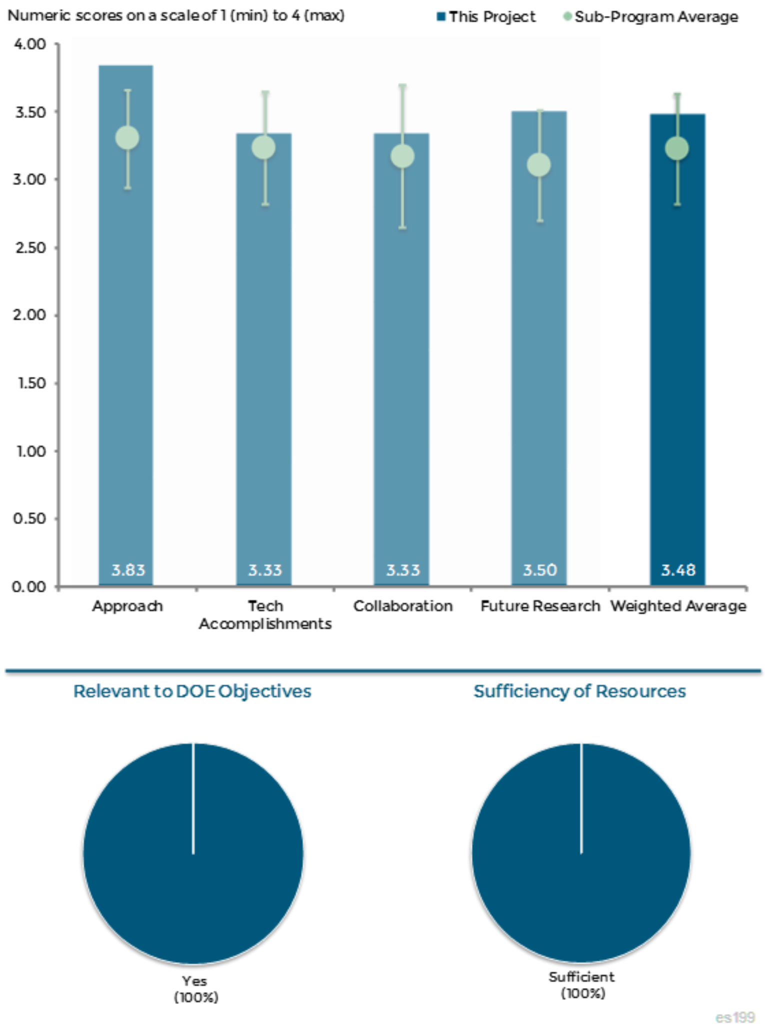


Figure 2-20 Coupling Mechanical with Electrochemical-Thermal Models Batteries under Abuse: Ahmad Pesaran (National Renewable Energy Laboratory) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The project objectives are well defined, and their linkage to the EV Everywhere Grand Challenge was described better than in any other poster the reviewer saw. The milestones were also well defined.

Reviewer 2:

To the reviewer, the coupled simulation approach seemed very good and the combination with experimental validation excellent. The reviewer recommended that early consideration be given the approach to the simulation/experimental cross-validation now to avoid excessive iteration between modeling and testing.

Reviewer 3:

The project is well designed, the reviewer said, and it addresses abuse conditions that could be experienced in PHEV applications.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The numerical and experimental results, the reviewer said, are very good.

Reviewer 2:

The reviewer described the technical achievement to date as good and suggested that recruiting a battery company to collaborate in achieving the model's validation on time might be advisable.

Reviewer 3:

The reviewer asked why the mechanical electrochemical-thermal (MECT) coupling relies on failure of the separator and subsequent contact of the anode and cathode as the failure mechanism. Noting that if the reviewer had interpreted the experimental data correctly, the mechanical tests indicated the separator is the most flexible material. In fact, the reviewer wondered, how did any of the mechanical measurements lead to input for the modeling studies, and vice versa. Are the groups working separately and then comparing results, the reviewer asked. The position of materials in the model was based on CT scans; the reviewer’s question referred to the mechanical properties studies. A project goal includes improving the safety aspects of battery design. It was unclear to the reviewer how the results from this study would change the composition or design of a battery.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer said the collaboration structure was very well defined and seemed to be working very well.

Reviewer 2:

The project is conducted by a very strong team consisting of industry and academic partners, the reviewer stated, with members working closely together.

Reviewer 3:

Noting that multiple institutions are involved, the reviewer found it hard to see if each group's studies relied on those of the others beyond the modeling partner relying on the CT images for structural input to the model.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The goals of the project are well defined, the reviewer averred.

Reviewer 2:

The proposed future research is reasonable, the reviewer said, and agrees with the original plan, but alternatives to the solutions of the challenges and barriers seem not to have been addressed.

Reviewer 3:

The reviewer asked how MIT's models will be improved, noting that more specific details would have been helpful. The reviewer again raised the question of how, with respect to safer battery designs, the future work leads to improved cell designs.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The understanding of multi-physics couplings on failure modes of electric vehicle battery components is critical to vehicle safety, the reviewer said, calling this a highly relevant project.

Reviewer 2:

The project will greatly aid future developmental efforts in new battery systems for advanced vehicle applications, the reviewer predicted.

Reviewer 3:

Safer battery designs will be helpful for the Li-ion battery market for plug-in electric vehicles (PEVs), the reviewer said.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

It appears there are sufficient resources to achieve the proposed goals as planned, the reviewer felt.

Reviewer 2:

The reviewer recommended that, given the high financial cost of the project, the collaborators determine a way to pull up the schedule and complete the project within budget, suggesting that a no-cost extension of the schedule is appropriate if the allotted time is not sufficient.

Reviewer 3:

The only information suggesting excessive or insufficient funds was the delay in the disbursal of funds to one participant, the reviewer observed.

Efficient Safety and Degradation Modeling of Automotive Lithium-Ion Cells and Pack: Christian Shaffer (EC-Power) - es200

Presenter

Christian Shaffer, EC-Power.

Reviewer Sample Size

A total of three reviewers evaluated this project.

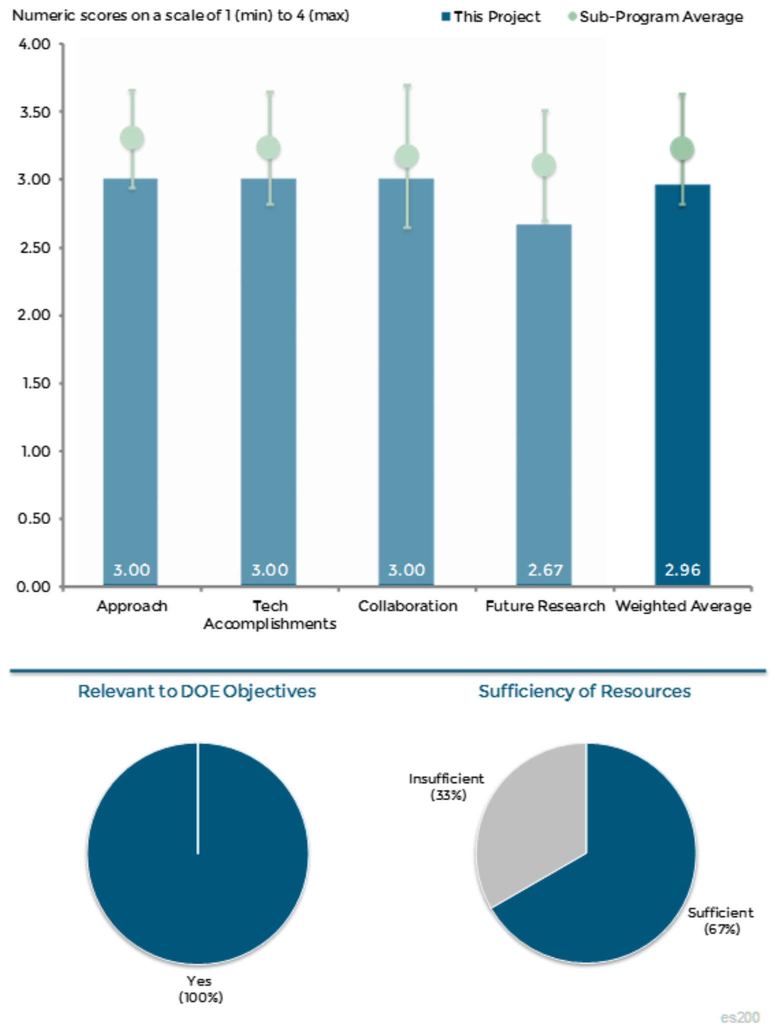


Figure 2-21 Efficient Safety and Degradation Modeling of Automotive Lithium-Ion Cells and Pack: Christian Shaffer (EC-Power) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The technical barriers are well addressed in this project, said the reviewer.

Reviewer 2:

The prominent role of experimentation and use of hardware to inform software development is valuable, the reviewer stated. However, the materials, conditions and parameters incorporated thus far are somewhat limited, particularly in view of the planned project completion date in September 2015. Noting that a lot of time and effort have been devoted to the nickel cobalt aluminum oxide (NCA) database, the reviewer was surprised to see that only one cell nail penetration had been done to date.

Reviewer 3:

The approach is good for the portion of the project that was presented, in the reviewer's opinion, although limited information was provided regarding the co-simulation with the structural mechanics module.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

Much of the planned work has been accomplished except life testing, the reviewer observed.

Reviewer 2:

Limited validation was presented, the reviewer stated, and it was not clear whether the objectives could be adequately completed and meaningfully validated between the AMR and October. The incorporation of electrode swelling the reviewer regarded as a meaningful achievement. The model appeared to the reviewer to be less sophisticated than other works in this space, and the limited validation results shown did not, in the reviewer's opinion, show particularly good correlation between predicted and experimentally obtained values. Many of the significant milestones are scheduled for completion in October, which is when the project will be completed, and this seemed to the reviewer to be quite ambitious, allowing little time to accommodate contingencies.

Reviewer 3:

The results for the serial versus parallel connected cells provide good insight into physical mechanisms for failure and clarify the benefit of the development of such tools, in the reviewer's opinion

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The collaboration roles are clear, the reviewer said.

Reviewer 2:

The team members of the project have a good collaboration with each other, in this reviewer's view.

Reviewer 3:

The hurdles associated with fabricating large-format cells have negatively impacted the results, and will likely limit the amount of testing realistically achievable between May and program conclusion, the reviewer remarked, adding that this might have been more proactively addressed through identification of an alternate source for test fabrication and testing as soon as the problems were identified.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer suggested collaboration with a battery company to leverage their efforts in fabricating cells and/or batteries for model validation in order to save time.

Reviewer 2:

A significant amount of validation work remains that will be crucial for a meaningful project outcome, the reviewer noted, thus, prioritizing the amount of pack-level safety validation testing to validate the 3/8 cells in series and in parallel results would be useful.

Reviewer 3:

The reviewer asked that the co-simulation strategy with the structural mechanics module be clarified. Specifically, what is the technical plan (it was not fully described), and what example case studies will be explored to demonstrate the capability of the developed platform.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This project supports the overall DOE objectives by developing battery safety and degradation models to aid battery design, the reviewer stated.

Reviewer 2:

EV battery safety is critical to promoting widespread adoption of highly efficient future vehicles, in the reviewer's opinion.

Reviewer 3:

While the goals are well-aligned with DOE goals, the reviewer said, output is inferior to that accomplished by other DOE-supported efforts in the same subject area domain.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

It seems, the reviewer said, there were insufficient primary or backup resources to execute the work plan. Noting that there are several months left, the reviewer conceded that observation might not be an accurate prediction, but believed that at present it was difficult to envision all milestones being achieved to the degree originally envisioned.

Electrochemical Performance Testing: Ira Bloom (Argonne National Laboratory) - es201

Presenter

Ira Bloom, Argonne National Laboratory.

Reviewer Sample Size

A total of two reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

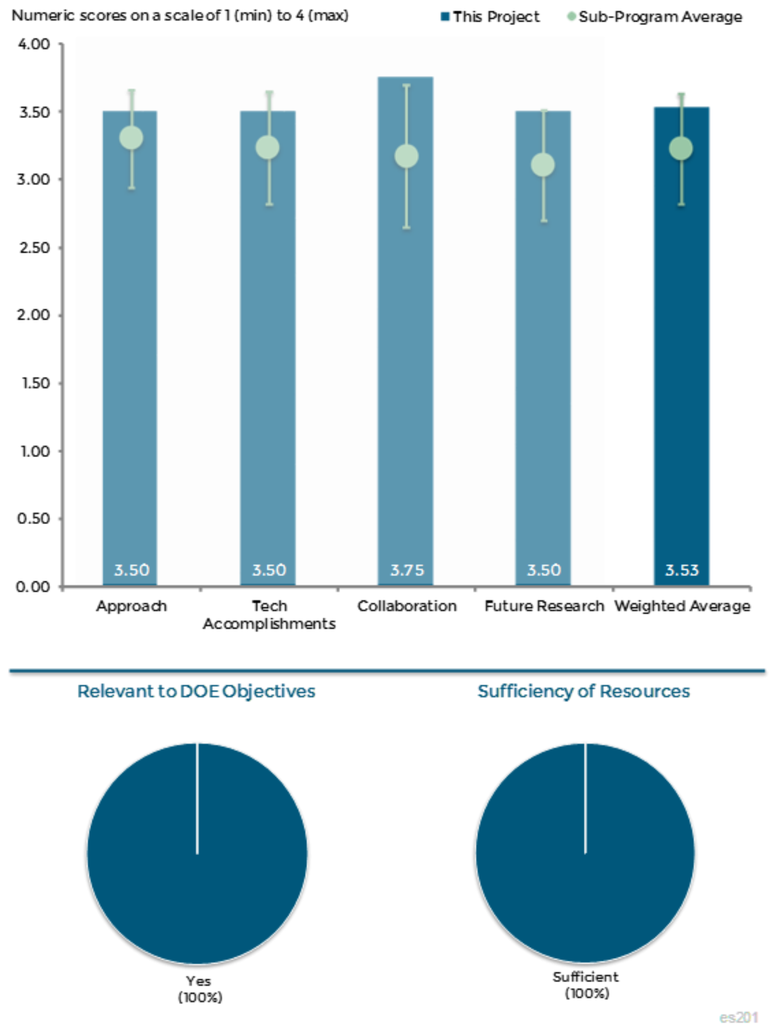


Figure 2-22 Electrochemical Performance Testing: Ira Bloom (Argonne National Laboratory) - Electrochemical Energy Storage

Reviewer 1:

The PI has a long-standing reputation for highly focused, well-planned projects, the reviewer observed.

Reviewer 2:

The reviewer professed puzzlement as to why such extremes – 40% and 100%– were chosen for SOC, believing 90% would have been a reasonable target because this could be chosen to help prevent overcharge while using more of the battery capacity. Likewise, ending charging at 40% other than under exigency of time seemed unrealistic to the reviewer. The reviewer expressed interest in seeing the effect of testing to a set number of cycles at 40% SOC, then completing more at 100% SOC, rather than doing only 40% or 100%.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer praised the results achieved by this team as generally world-class, adding that the current data also reflect the meticulous nature of the test planning, execution and data analysis. However, the reviewer was puzzled by the disparity of test results from the Idaho National Laboratory (INL) and ANL who followed the same test protocols.

Reviewer 2:

The future work mentioned in the 2014 poster was addressed in 2015 and several factors were evaluated in fast charging experiments. The reviewer wondered if any publications resulted from this work.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

National laboratories are well known for collaborative work, the reviewer observed.

Reviewer 2:

The PIs are working with multiple companies and are comparing results with testing protocols used in China, was this reviewer's observation.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The work plan is always well-thought out and thorough, said this reviewer.

Reviewer 2:

The project milestones provided were deemed inadequate by the reviewer. The reviewer considered that presenting test results at quarterly meeting does not include specific information on dissemination of results to the general public or scientific institutions. The Future Work slide in the presentation provides more useful information, but it is unclear when the work will be completed because the milestones only go through September 2015.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

Terming the project highly relevant, the reviewer praised the national laboratories as generally providing high-quality, unbiased evaluation of battery technologies.

Reviewer 2:

Improvement in battery performance would support their increased incorporation into EVs, decreasing the need, at least on a percent basis, for petroleum-fueled vehicles.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer questioned the applicability of this question to national laboratories.

Reviewer 2:

It was unclear to the reviewer if any additional resources were needed to complete testing.

INL Electrochemical Performance Testing: Jon Christophersen (Idaho National Laboratory) - es202

Presenter

Jon Christophersen, Idaho National Laboratory.

Reviewer Sample Size

A total of two reviewers evaluated this project.

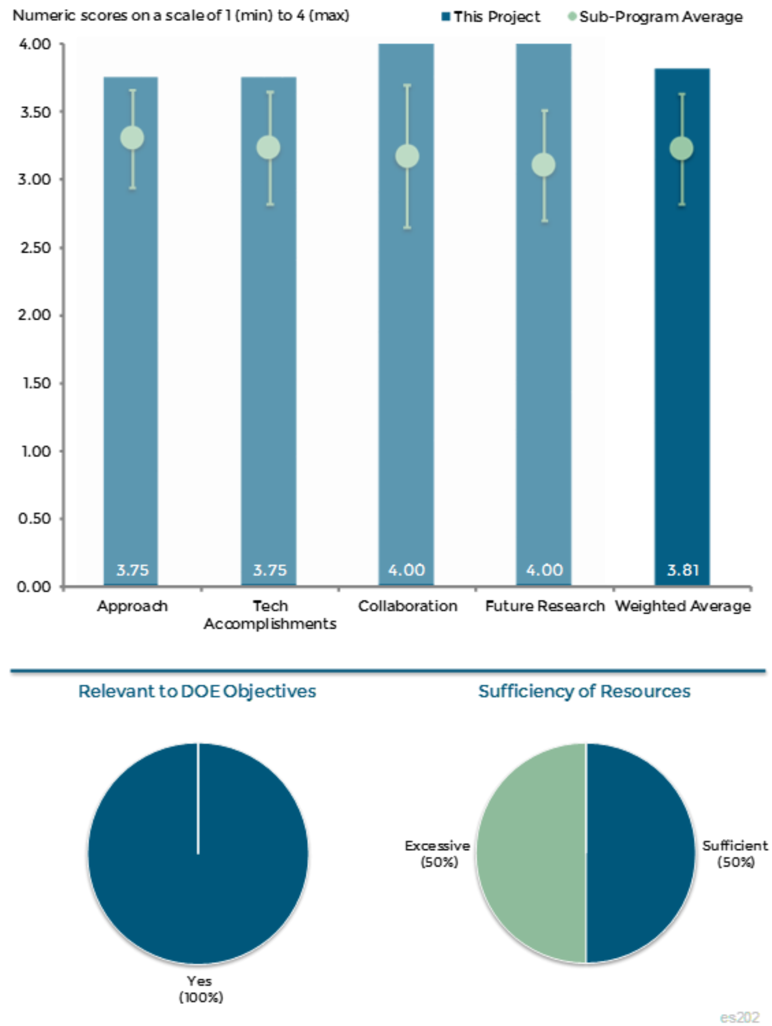


Figure 2-23 INL Electrochemical Performance Testing: Jon Christophersen (Idaho National Laboratory) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The approach is thorough, the reviewer said, the analysis of multiple performance factors allowing identification of the reasons for failure. Inclusion of vibrational monitoring adds a needed metric in evaluative tools, the reviewer added.

Reviewer 2:

INL has a long-standing reputation for highly focused, well-planned projects, the reviewer stated.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

Praising the project team for its routine execution of high-quality testing studies, the reviewer added that their contribution to the generation of world-class testing protocols/manuals can hardly be overstated. The results of life modeling using real-life data over a long period of time are very valuable, the reviewer concluded.

Reviewer 2:

The reviewer called the publication of manuals and patents impressive, but would have liked to have seen contributions to the peer-reviewed literature and considered that this seemed like a great opportunity to reach the broader public as well, perhaps through collaborative publications with science writers. The reviewer was unsure, however, if that is something DOE requires through this funding mechanism.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

Collaboration with many other institutions, in the form of testing the performance of other institutions' batteries, the reviewer said, is clearly evident and abundant.

Reviewer 2:

The reviewer noted extensive collaboration with various laboratories and organizations.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

Testing of articles that were used to predict life, the reviewer urged, should be continued as long as possible to generate a robust baseline data set.

Reviewer 2:

The reviewer asked why the Tech-to-Market workshop is limited to industry. The reviewer expressed the belief that researchers from national laboratories and academia, too, could benefit from learning about testing protocols. The reviewer speculated that perhaps there is another outlet through which this information could be disseminated.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

Absolutely, the reviewer said; INL is an integral part of battery development process/testing.

Reviewer 2:

By providing analysis to national laboratories and companies on performance metrics, the projects' PIs are enabling more reliable data for performance that may lead to better integration of lithium-ion batteries in the battery market, the reviewer stated.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

While noting that many channels are available, the reviewer wondered if even more progress could be made by further equipping the facilities with more channels and temperature-controlled chamber(s).

Reviewer 2:

Unless the funds are used to procure/upgrade equipment, the reviewer said, they seem to be a bit on the high side.

Battery Safety Testing: Christopher Orendorff (Sandia National Laboratories) - es203

Presenter

Christopher Orendorff, Sandia National Laboratories.

Reviewer Sample Size

A total of two reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

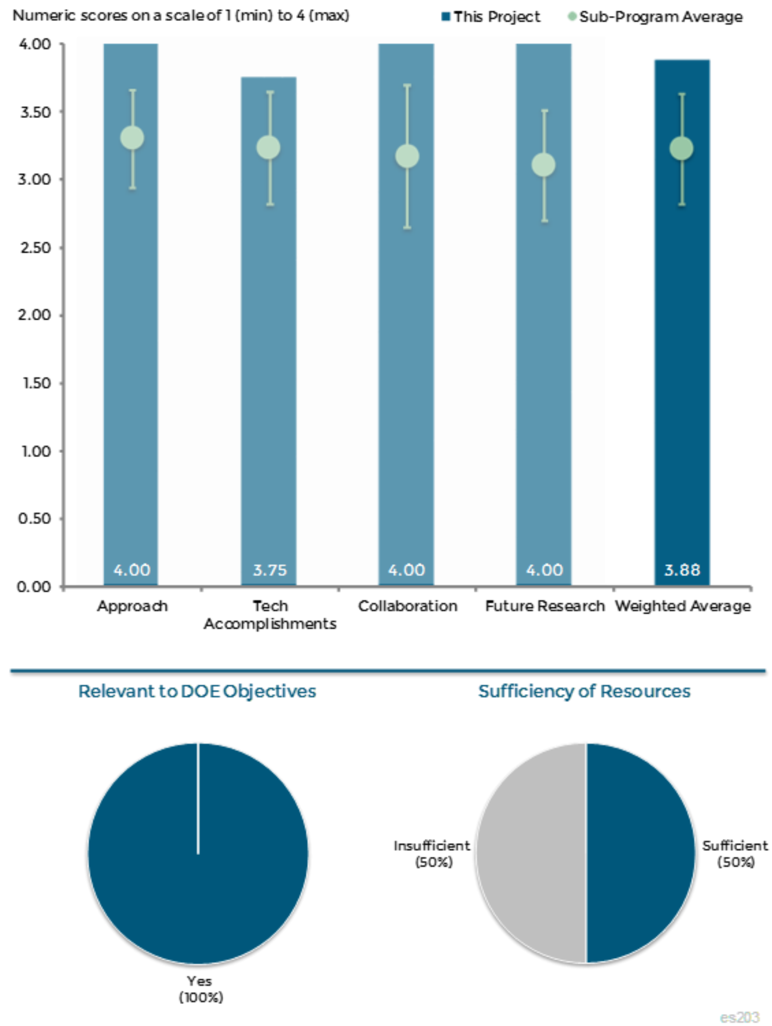


Figure 2-24 Battery Safety Testing: Christopher Orendorff (Sandia National Laboratories) - Electrochemical Energy Storage

Reviewer 1:

The reviewer commented on the project’s very well-organized, focused work plans and noted that SNL meticulously carried out planning for testing of DOE-sponsored research articles.

Reviewer 2:

The work is thorough and diverse, the reviewer said, noting the failure propagation test and car crash-worthiness studies with particular approval. The reviewer further noted the PI’s response to reviewer comments about the difficulty in predicting failure response, saying it was reasonable and pointing out that the project team had to start somewhere.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer deemed the results to be benchmarks in the industry. Tests such as failure propagation, for example, still engender considerable controversy surrounding methods, the reviewer observed, suggesting it might be worth pursuing multiple options to evaluate the pros and cons of the various methods.

Reviewer 2:

Many setups deliver a variety of performance testing abilities, the reviewer said, adding that the combination of modeling with experiment is appropriate and should be continued. The reviewer expressed support for the evaluation of cells from multiple manufacturers.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

Testing includes multiple institutions and companies in all project areas, the reviewer observed, and the collaborative efforts are reflected in the authorship of resulting publications.

Reviewer 2:

Noting extensive collaboration with various organizations and labs, the reviewer suggested that an important partner could be Chinese national laboratories in order to exchange, develop and harmonize test protocols.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

Given the current emphasis on development of Li metal-based systems, the reviewer said, it will be instructive to include and benchmark the abuse tolerance of Li metal battery systems such as those commercially available from Sion or Bollore. The reviewer suggested collaboration with Chinese national laboratories.

Reviewer 2:

The proposed future research seemed reasonable to the reviewer based on results obtained to date. However, the reviewer found the specifics of the proposed research difficult to critique due to the amount of detail provided.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

SNL's role in DOE's efforts to develop better batteries to displace petroleum cannot be overstated, the reviewer emphasized.

Reviewer 2:

Improving performance and understanding of performance and failure in Li-ion batteries may allow for improved battery design and/or management systems to create more reliable systems, the reviewer suggested. The reviewer concluded that preventing failure may lead to increased incorporation of Li-ion batteries into EVs, a factor critical to the displacement of petroleum.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

Considering how costly abuse-testing studies are, the reviewer was unsure the current level of funding is sufficient.

Reviewer 2:

The laboratories have set up systems to test multiple aspects of performance and failure and seem to have made good use of the resources allocated for them, the reviewer said.

Battery Thermal Characterization: Matthew Keyser (National Renewable Energy Laboratory) - es204

Presenter

Matthew Keyser, National Renewable Energy Laboratory.

Reviewer Sample Size

A total of two reviewers evaluated this project.

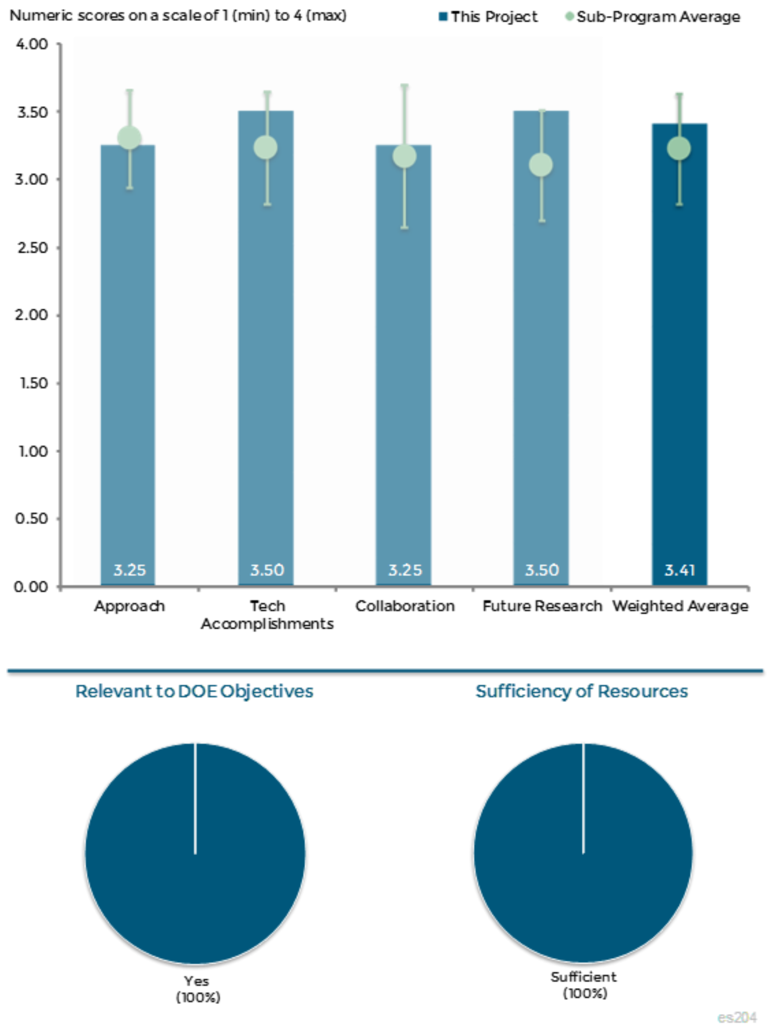


Figure 2-25 Battery Thermal Characterization: Matthew Keyser (National Renewable Energy Laboratory) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer complimented the project work plan as well-planned and well-focused.

Reviewer 2:

Noting that the PIs had measured thermal and electrochemical performance of Li-ion batteries, the reviewer found it difficult to see how the individual experiments are related, acknowledging that this difficulty might result from a lack of familiarity with the project team's specific research. All experiments seem to involve temperature and cycling, the reviewer observed, but questioned whether one experiment leads to another, for example, or multiple experiments are combined for a more thorough understanding. The reviewer also believed it would have been expected before any of these tests were done that improperly designed thermal management systems can lead to a cell-to-cell temperature spread. The reviewer also expressed an interest in knowing what cell chemistries were tested as far as typical and new chemistries have been noted.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The high-quality thermal studies data NREL presented are extremely useful to the developers, the reviewer stated. The reviewer also noted the unique calorimeter the project team have developed, its size in particular, calling it a valuable tool for characterizing cells of varying sizes and shapes. Thermal imaging, efficiency and entropic data are valuable parameters for the researchers, the reviewer concluded, calling NREL the go-to lab for procuring reliable thermal data.

Reviewer 2:
The reviewer found the entropic studies quite interesting to learn about, but was unsure how that will lead to improvements in design. The reviewer also noted that publications in peer-reviewed literature were not included in the list of accomplishments, asking if this was not important for the project.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer discerned excellent collaboration with various laboratories and organizations.

Reviewer 2:
While several partners were listed, the reviewer noted, it was not clear how the PIs are working with those partners. For example, the reviewer said, it was unclear if the PIs are testing batteries from all or some of the partners.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
Pack-level studies using the OEM drive-profiles will be very interesting, the reviewer predicted, suggesting the possibility of characterizing cells/packs at end of life.

Reviewer 2:
The reviewer wondered how the PIs propose to reduce cell-to-cell temperature variations. Learning there are thermal variations does not necessarily lead to the conclusion that a solution to temperature variation is the next step. The reviewer asked whether work with room-temperature refrigerants means that the next year will involve thermal analysis when liquids are surrounding battery exteriors. If so, the reviewer questioned how the temperature of the battery itself will be measured, rather than that of the liquid.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
Affirming that the project is supportive of DOE’s petroleum replacement goal, the reviewer called thermal characterization and modeling important for the development of efficient cells/batteries.

Reviewer 2:
The information developed in the project may lead to better batteries for PEVs, the reviewer said.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The funding level seemed appropriate to the reviewer.

Reviewer 2:
No deficiency in results is apparent, the reviewer said.

New High-Energy Electrochemical Couple for Automotive Applications: Khalil Amine (Argonne National Laboratory) - es208

Presenter

Khalil Amine, Argonne National Laboratory.

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

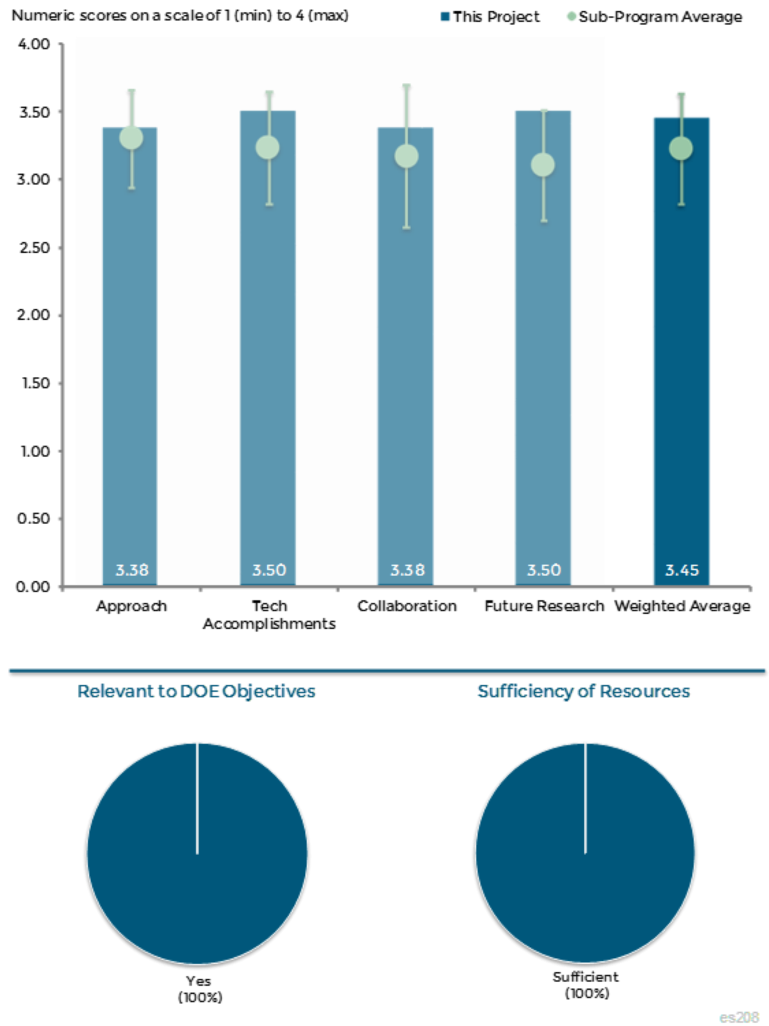


Figure 2-26 New High-Energy Electrochemical Couple for Automotive Applications: Khalil Amine (Argonne National Laboratory) - Electrochemical Energy Storage

Reviewer 1:

The approach seemed very comprehensive to the reviewer, who noted the anode, electrolyte and cathode were all combined to achieve a high-energy battery, with long calendar and cycle life. The project team are strongly focused on the critical barriers, the reviewer concluded.

Reviewer 2:

The FCG materials seem to be a viable approach to increase the lifetime and capacity of NMC-based materials. The reviewer termed the cathode part of the project impressive and said the combination of high-resolution analytical techniques and electrochemical investigations proofs the concept very well. The reviewer welcomed the use of SiO-SnCoO as anode material as opening an alternative to the commonly used Si/Si-C material.

The anode material target of 900 mAh/g, the reviewer said, can be sufficient for the DOE PHEV-40 target. It would be of additional benefit, the reviewer concluded, to investigate the potential of the material to exceed 1,000 mAh/g and thus also to address EV application.

Reviewer 3:

The full concentration gradient (FCG) cathode material appears to be far ahead of the Si-based material development, the reviewer noted, which appeared to be reflected in the basic understanding of the system. The reviewer continues to be concerned that with all the work on multiple Si-based systems – not just that presented here – there appeared to be a fairly significant lack of fundamental understanding around the material sets. This, the reviewer went on, is not a concern regarding the present work in this data, but all work associated with these materials.

Reviewer 4:

The key barriers that must be addressed, the reviewer stated, is long calendar and cycle life, but it is not clear how to address this challenge. In particular, the reviewer said, a solution for the instability of the SEI layer and attack by dissolved Mn from the surface of the FCG cathode to the anode side were not clearly discussed or planned. Also, the current anode system shows poor capacity and cycle life, problems the reviewer said could not be solved by addressing only the binder.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer called the progress of the work within the past year quite impressive, showing the project team's effective and target-oriented way of working. The scientific approach and experimental methods, the reviewer said, are well chosen and the evaluation of the best binder option was very interesting. The capacity and cycling stability of the cathode material could be well improved, in the reviewer's view, but a capacity above 200 mAh/g could only be reached at 4.5 V with negative impact on cycle life. The capacity advantage disappeared after 50 cycles and might be even worse at higher cycle numbers, the reviewer said. At present, the reviewer observed, FCG has a mean composition of 622 to adjust to the 622 baseline, but recommended that Ni content be increased in the next step to meet the target. For the anode alloy with optimized binder LiPAA, good cycle life was shown for alloy contents of 33%, the reviewer noted, which does not lead to the targeted capacity. The reviewer recommended adding an investigation of cycle performance as a function of alloy content. The reviewer concluded by calling attention to a table in the presentation showing the BatPaC cell design results and recommended adding a line with the DOE cell targets and an additional baseline 622 versus graphite to show the different effects of new anode and cathode materials.

Reviewer 2:

The reviewer found the thermal stability data on the NMC 622 FCG very compelling, adding that it is easy to understand that as the Mn content increases toward the surface of the particles, the powder will be more stable. However, the reviewer continued, higher-than-baseline capacity of the gradient powder reported by the authors appears more difficult to understand. The reviewer speculated that there could be small fluctuations in the overall Ni content of the two cathode powders, with the gradient material having a little more Ni. Poor distribution of the negative active material associated with the electrode processing of the anode (SiO-SnCoC-MAG) seems a reasonable explanation for the poor performance in a full cell, the reviewer concluded.

Reviewer 3:

As the reviewer noted earlier, there appeared to have been solid progress made on the FCG material, but less on the Si material.

Reviewer 4:

The reviewer noted good progress, although the cycle life of the anode side still needs significant improvement. For the cathode, the reviewer said, optimization may be achieved further by considering particle size and grain structure. The reviewer observed that no detailed study on rate capability was done and that there was discussion of abuse tolerance even though that is one of barriers it was desired to address.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

Collaboration with other institutions seemed very good to the reviewer, who noted that they complemented each other.

Reviewer 2:

The collaboration is well balanced and seemed to work effectively, in the reviewer's opinion. The reviewer voiced the expectation that the focus of the different partners will be continuously adjusted to the findings, for example to results on binder or anode electrode processing.

Reviewer 3:

Noting the presence of several partners in the overview slides, the reviewer said the outcome of the SEI and facility scale-up were not shown.

Question 4: Proposed Future Research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer termed the project team a solid group of high-quality contributors.

Reviewer 2:

After an independent confirmation of a better electrochemical performance, including capacity, for the gradient powders is achieved, the reviewer said, strong efforts should be directed toward a scale-up of the production process. The authors mentioned the production of one kilogram of cathode powder per batch, leading the reviewer to wonder if the process is scalable to 500 to 1,000 kg.

Reviewer 3:

The proposed next steps, the reviewer said, address the present challenges or missing results. The reviewer also directed attention to earlier comments on future work included in the Comments on Technical Accomplishments and Progress section.

Reviewer 4:

Abuse tolerance must be added in the future plan, the reviewer urged, as it was not discussed or addressed in spite of being one of the key target elements.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The project is strongly related to the objective of petroleum displacement, the reviewer stated, because stable, high-energy cathode powders are very important in this area.

Reviewer 2:

The reviewer called higher-energy-density cells obvious targets for DOE objectives.

Reviewer 3:

The work is aimed at achieving a higher battery energy density necessary to increase the range and market chances for future PHEVs and EVs, the reviewer observed.

Reviewer 4:

Development of high cathode and anode is essential for enabling PHEVs and EVs, according to this reviewer.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

If the authors plan to scale up the processes, the reviewer qualified, the resources are not sufficient.

Reviewer 2:

The reviewer observed that budgets were not broken down by individual investigator efforts.

High-Energy High-Power Battery Exceeding PHEV-40 Requirements: Jane Rempel (TIAX) - es209

Presenter

Jane Rempel, TIAX.

Reviewer Sample Size

A total of four reviewers evaluated this project.

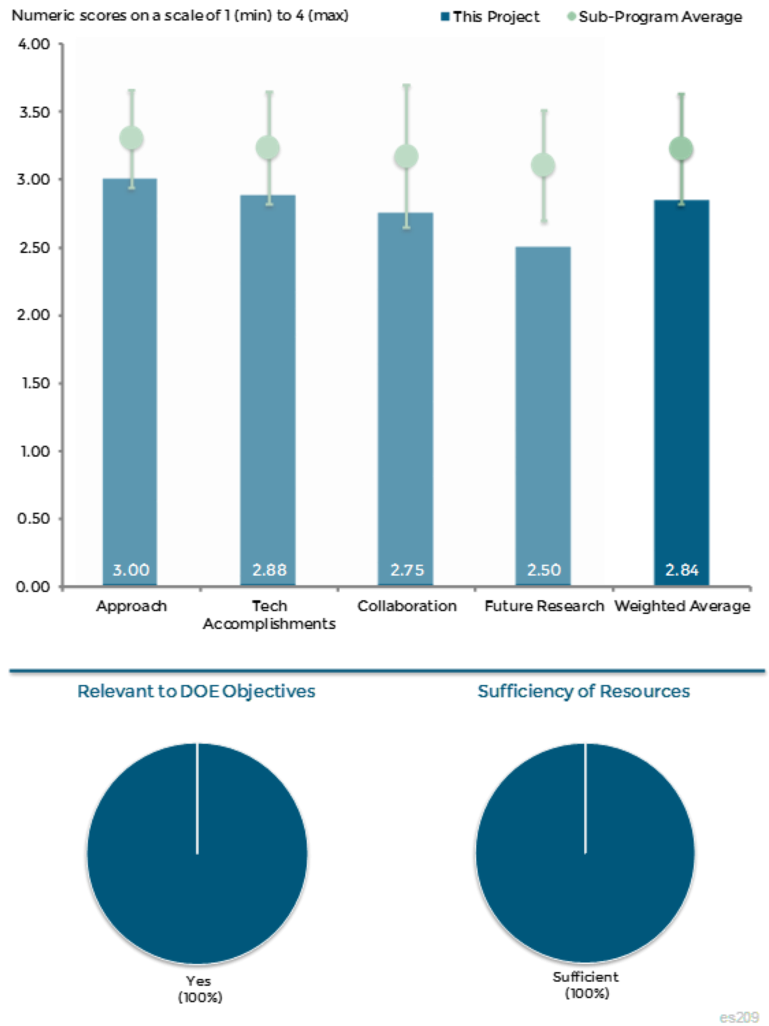


Figure 2-27 High-Energy High-Power Battery Exceeding PHEV-40 Requirements: Jane Rempel (TIAX) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that the project team is well focused on the critical areas and should overcome most barriers. It was apparent to the reviewer that that the authors have managed to overcome potential difficulties associated by working with critical suppliers.

Reviewer 2:

The reviewer commented that the approach appears to be to use a fairly well characterized and well performing cathode material (CAM-7 in this case) and matched it with Si-based anode structures that have been provided as potential counterpart anode electrode structures. The reviewer noted that with every reviewed cathode/Si anode proposal, there appears to be a lack of fundamental understanding and development around the Si anode limitation, which is concerning. The reviewer opined that there is certainly a place for this work being performed, and there is nothing wrong with it, but also noted that the key to making any of these designs work appears to be in the Si side of the equation.

Reviewer 3:

The reviewer noted that the principal approach in terms of set of material is reasonable and similar to the comparable projects, but there are no details disclosed on how to further develop the material properties in order to meet the targets.

Reviewer 4:

The reviewer expressed that the uniqueness of the project was not very clear because it seems the team relies significantly on the vendors and that the presentation slides do not represent the actual research activity. For example, hard C, which was not actually used. The reviewer also noted that the slide and presentation information do not convey detailed technical discussions.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer said that it will be interesting to see the specially designed set-up used to monitor the rise in internal cell pressure due to the silicon anode. Slide 6 shows the specific capacity obtained using a low-loading electrode. The reviewer suggested that at some point, the authors should mention the electrode loading to better judge its performance for it could be of interest to know how reproducible is the data obtained from different batches of cathode powder.

Reviewer 2:

The reviewer observed that the graphite/CAM-7 work appears to be performing as it should which is fine, but is a somewhat mature data set which is not necessarily in need of development funding. The reviewer also noted that the Si-based cell has baseline promise, but the key to further progress really lies on the Si materials developers.

Reviewer 3:

The reviewer commented that for the graphite material, the capacity retention looks good, but, 1 Ah at C/20 discharge rate is low compared to the commercial products. However, the reviewer pointed out that the Si cell shows poor cycling performance.

Reviewer 4:

The reviewer noted that the milestone overview between 2014 and 2015 is unchanged where it just states scheduled and it is unclear which milestones are completed. The baseline cell (CAM-7/Graphite) with a cathode loading of 2 mAh/cm^2 and 1.8 ampere-hour (Ah) for an 18650 cell is quite low compared to the state of the art. The reviewer also stated that the cycling data of the baseline cell seems to be the continuation of the cycling test shown in 2014, but the capacity retention of the 2014 and 2015 curves, in regards to DOE, does not fit. There is no information given regarding a further improvement of the baseline cell. The reviewer observed that most of the presentation shows results of the baseline cell. No information is given regarding material and/or electrode development.

The reviewer added that the achieved capacity of 2.85 Ah with a cathode loading of 4 mAh/cm^2 can be achieved with graphite where to compare baseline cell with 1.8 Ah and cathode loading 2 mAh/cm^2, and that an improvement by the Si based anode is not obvious. The reviewer expressed that the pressure variation during cycling is a good experiment, but it is difficult to interpret as the amount of Si in the anode and the packing density of the jelly roll within the 18650 cell is not given. As the capacity is not too high, it is assumed that the pressure build up could be substantially higher when the cell volume is better utilized.

The reviewer also noted that the capacity fade within 30 cycles is by far too high. No explanations regarding root cause or measures to improve are given. Additionally, the reviewer remarked that the details in presentation es260 are quite general and cannot be linked to the open issues mentioned above.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

It was apparent to the reviewer that the project team has a good collaboration with the suppliers. As explained on Slide 20, in future projects, the team is planning on having a stronger collaboration with DOE laboratories.

Reviewer 2:

The reviewer stated that the project work is done without collaborative partners. The level of material supplier input regarding knowhow and analysis cannot be judged and is also not obvious in the results.

Reviewer 3:

The reviewer said that here is no collaboration except for material suppliers. Also, no details are provided for the interaction with collaborators.

Question 4: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

It was apparent to the reviewer that the authors are overcoming most barriers. Gen 1 CAM-7/Si cells are providing power and higher energy density on 18650 cells. The reviewer pointed out that the limiting factor is the capacity retention of the Si-containing anodes. Blended anodes or pre-lithiation are mitigating strategies. The reviewer suggested the team to scale up initiatives of the CAM-7 high-energy and that high power cathode should be addressed in the future.

Reviewer 2:

The reviewer commented that the project team should continue to optimize the design of Si anodes and opined that this project has been going on for a long time.

Reviewer 3:

The reviewer said that the next steps do not disclose the technical actions to be taken. Taking into account the present low cycle life of the target cell, the achievement of the final project goals is questionable.

Reviewer 4:

The reviewer stated that there are no specific plans for improving cycle life, calendar life, and temperature range, which are all described in the overview slides.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer confirmed that the project team is very focused on the development of high-capacity Li batteries, which is very much aligned with petroleum displacement.

Reviewer 2:

The reviewer expressed that high-energy density cells clearly relate to the U.S. Department of Energy (DOE) objectives.

Reviewer 3:

The reviewer remarked that the development lithium-ion battery systems that meet and exceed the PHEV-40 performance and life goal is necessary for achievement of DOE objectives.

Reviewer 4:

The reviewer stated that the work is aimed towards achieving a higher battery energy density necessary to increase the range and market chances for future PHEVs and EVs.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented that not much is said about the working relationships with the material suppliers and maybe the resources are not sufficient.

Reviewer 2:

The reviewer stated that detailed budget information is not available.

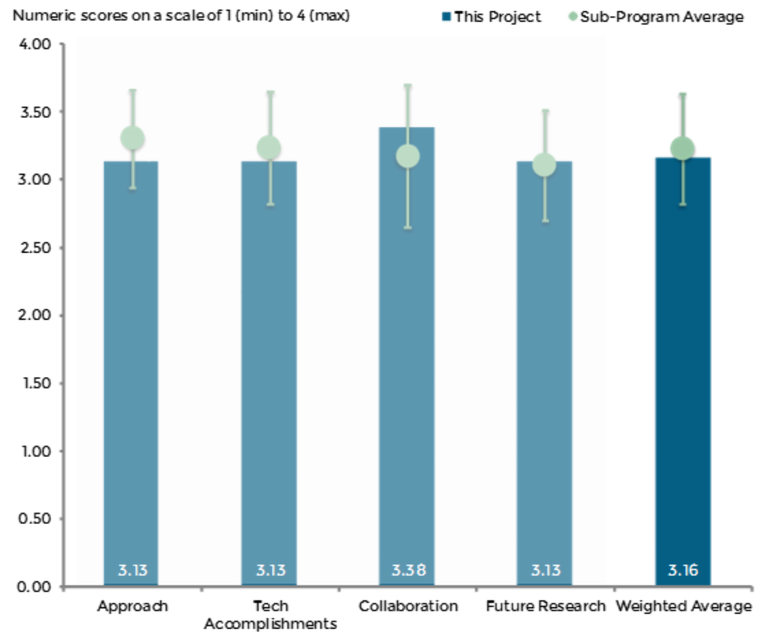
Advanced High-Energy Lithium-Ion Cell for PHEV and EV Applications: Jagat Singh (3M) - es210

Presenter

Jagat Singh, 3M.

Reviewer Sample Size

A total of four reviewers evaluated this project.



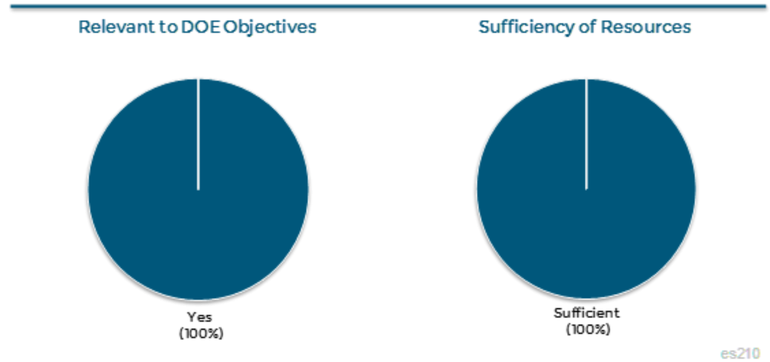


Figure 2-28 Advanced High-Energy Lithium-Ion Cell for PHEV and EV Applications: Jagat Singh (3M) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer concluded that the approach is good leaning to excellent. As will be seen in collaborator section, at least this work has subject specific experts contributing in all major fields of concern.

Reviewer 2:

The reviewer said that it is encouraging that nanostructure-based Si alloy anode and advanced cathode both demonstrate improvement in capacity as cycling number increases. However, the demonstrated cycle number is not sufficient for commercialization. The reviewer pointed out that another concern is the structural instability due to mismatch for the core shell cathode material.

Reviewer 3:

The reviewer expressed that the approach is reasonable and comparable to similar projects.

Reviewer 4:

The reviewer noted that the advanced cathode development seems very interesting, in particular, the NMC 622. However, even though the presentation showed improvements, it is not very clear about the deliverables.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer noticed that, as with other programs of this type, and there are several, the cathode technology is far ahead of the anode technology. The reviewer is in favor of all advanced design data sets as compared to a cathode/graphite control cell. 3M Company is a long time developer of Si anode material and has a strong commercial focus. Understanding where the technology compares to state of the art baseline, for example graphite, seems reasonable to the reviewer as a comparison to make.

Reviewer 2:

The reviewer stated that the authors managed to produce advanced anode and cathode materials of higher capacity. Cycle life improvement with additives one and two seems impressive; however not much information is provided. Similarly, the reviewer noted that with the high-voltage NMC cathode in Slide 8, the new NMC cathode powder seems to double the cycle life.

Reviewer 3:

The reviewer expressed that the demonstrated rate capability is still not sufficient in terms of cycle life and C-rate. The improvement must be demonstrated over 1,000 cycles to be competitive commercial product, and the technical issue and surface stability must be addressed to achieve the target.

Reviewer 4:

The reviewer noted that the improvements in the Si-alloy anode shown are minimal and far from target, from 66% to 70% capacity retention after 500 cycles. Moreover, testing conditions like voltage and C-rate are not given. For the cathode material capacities above 200 mAh/g are only reached at high-voltage of 4 and/or 6 V. Accordingly it shows high-capacity fade of 20% after 100 cycles. The reviewer pointed out that the slide regarding the core shell material from partner, Umicore, is misleading as it is not the material used in the previous chart and in the subsequent full cell tests, for the composition, in regards to DOE, does not match. Test of electrolytes and additives are done with different test conditions such as room temperature (RT), C/5 discharge rate verses 30° Celsius (C), C/3 discharge rate.

The reviewer recommended harmonizing the test conditions, and the cycling test for the additives stops at 75 cycles. It can be expected that even the best option (i.e., additive 1 + additive 2), will fall off with increasing cycle number. The reviewer’s recommendation is to extend the cycling tests. Results in 18560 cells are referred to advanced chemistry but no explanation is given of the material optimizations. Moreover, just the rate capability is shown, where the most important would be the cycling performance.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that the project team has a very good collaboration set and the reviewer expressed an appreciation of the data provided.

Reviewer 2:

The reviewer stated that the project team’s collaboration seems to be very good which includes universities, companies, and national laboratories.

Reviewer 3:

The reviewer remarked that project partners are well recognized companies or laboratories with high competence in the field and are able to address all relevant challenges. However, the progress shown, in regards to DOE, does not fully reflect this strong partnership where a close interaction between the partners was not obvious from the available material. The reviewer concluded that it is recommended to strengthen the interaction.

Reviewer 4:

The reviewer observed that there is a good project team collaboration with strong multidisciplinary teams. However, the challenges for multiple organizations, such as lack of effective communications and feedback updates, must be resolved. The reviewer states, for instance, sample preparation, electrolyte, binder, optimization, evaluation/analysis are all conducted in different research groups, and how effectively the teams communicate and exchange the data will be an issue.

Question 4: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer noted that the efforts to scale-up cathode and anode materials is going to be important at the cell level. However, in future presentations, the reviewer expressed that the authors should give some idea on how scalable the production processes are for a more massive production of those powders.

Reviewer 2:

The reviewer mentioned that principal direction of future research is reasonable, but taking the remaining time into account seems to be critical to reach the targets, and expressed that it would be desirable if a more detailed action plan were established for the last few months.

Reviewer 3:

The reviewer commented that a plan for cycle life improvement is not included in detail, and especially concluded that the mechanical failure and SEI layer instability must be addressed.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer pointed out that yes, the project is focusing on the delivery of high-capacity batteries that, at some point, could be used for electric propulsion, and this is much related to petroleum displacement.

Reviewer 2:

The reviewer observed that high-energy density cells are obviously in the interest of the DOE objectives.

Reviewer 3:

The reviewer expressed that advanced a high-energy Li-ion cell for PHEV and EV applications is urgently needed for achieving the DOE objectives.

Reviewer 4:

The reviewer stated that the work is aimed towards achieving a higher battery energy density necessary to increase the range and market chances for future PHEVs and EVs.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer observed that the project is almost complete at his time, and the team made substantial progress, but cycle life could be a challenge.

Reviewer 2:

The reviewer noted that the costs were not broken down by individual efforts.

High-Energy Lithium Batteries for PHEV Applications: Subramanian Venkatachala (Envia Systems) - es211

Presenter

Subramanian Venkatachala, Envia Systems.

Reviewer Sample Size

A total of four reviewers evaluated this project.

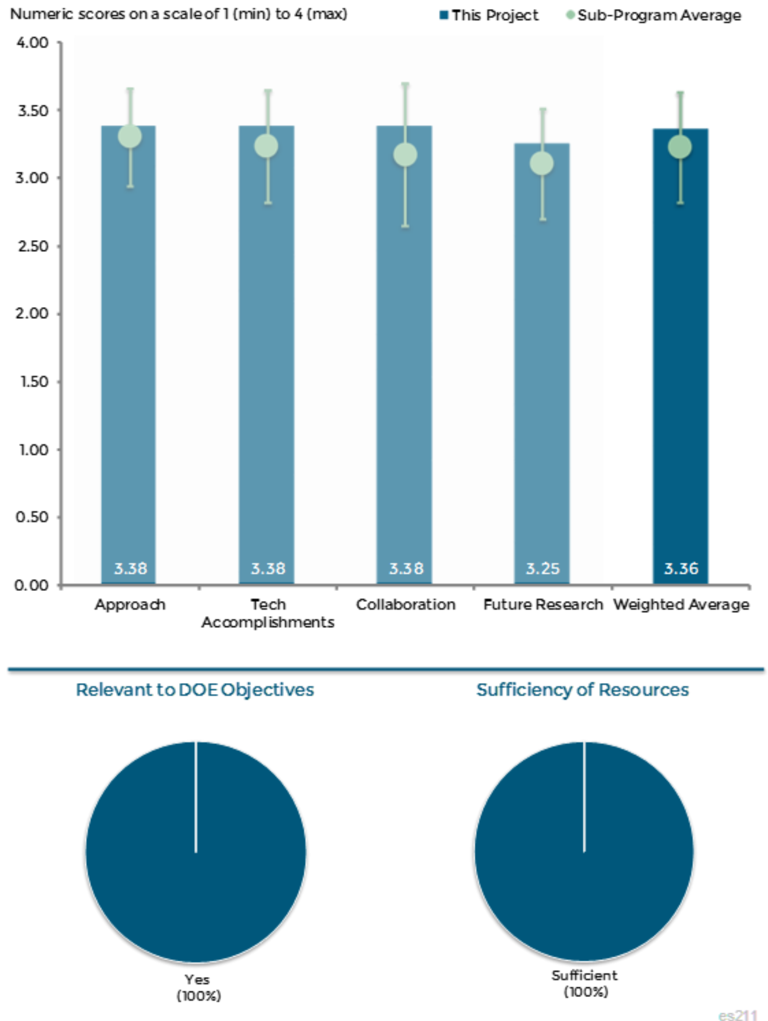


Figure 2-29 High-Energy Lithium Batteries for PHEV Applications: Subramanian Venkatachala (Envia Systems) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer praised that the approach has some fundamental analysis of the direct current (DC) resistance rise of the cathode material, as for in most of these presentations, the Si anode portion of the approach is more of an afterthought and really needs to occur within a dedicated program.

Reviewer 2:

The reviewer pointed out that the approach is sharply focused in the critical areas, where the transition from HCMR-XLE towards HCMP-XE seems appropriate based on the experimental evidence.

Reviewer 3:

The reviewer pointed out that the strategy based on root cause is well organized. However, the focus should be made based on analysis, and not trial and error. The reviewer expressed that the atomic layer deposition (ALD) coating, competition between mechanical stability, and species transportation that may be hindered by thick layer, must all be considered and optimized.

Reviewer 4:

The reviewer noted that the technical approach in the particular coating of the Mn-rich material is reasonable. The necessary high capacities above 200 mAh/g are only achieved within the large voltage window between 4.6 and 2.0 V, where the high upper cutoff voltage and the quite low mean voltage might be disadvantageous, and thus, the cycle life for the first and energy density for the latter.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer opined that the cathode progress was quite interesting.

Reviewer 2:

The reviewer noticed that due to the well-structured and scientifically sound way of working, the project team has made substantial progress in the past year, and expressed appreciation that the results were shown in reasonable detail, even when the approach was not successful. When looking at the cathode material results, it is questionable whether the open challenges including structural phase changes can be solved. Moreover, the large voltage span is an additional challenge. The reviewer added that regarding the anode material, it is not obvious that there is a substantial in-situ graphene production, and moreover, in the case that graphene is produced, it improves the performance, but only 40 cycles were shown. It is recommended to show the presence of graphene experimentally and analytically and present a model of how this increases the performance and/or the lifetime. The reviewer said that the results on the binder investigations were interesting and give good hints for the direction of future work. The full cell testing of high capacity manganese rich (HCMR) graphite shows quite good cycling but at substantial lower voltage than 4.4 V as compared to the results shown for the material development. The reviewer concluded that only capacities below 200 mAh/g are achieved and are also possible with Ni-rich NMC for example, and that it is recommended that the project team make a critical evaluation of the particular HCMR approach at the end of the project.

Reviewer 3:

The reviewer acknowledged that the authors have done an appreciable amount of work with different types of coatings on the cathode powders, and it seems that the formation of the spinel like structure will always develop as the material is cycled. The reviewer mentioned that project team should probably do some temperature stability studies on their cathode powders in the future.

Reviewer 4:

The reviewer noted that even though using XE verses graphite shows good results, it should be extended to high-energy anode material, and the explanation for observed phenomena must be made to utilize the observed results.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted that the project team has very good collaboration with other institutions, such as Lawrence Berkeley National Laboratory (LBNL) and General Motors.

Reviewer 2:

The reviewer remarked that the project team collaboration is small but with competent partners, and thus, allows effective cooperation with the partners who seem to well coordinate their efforts, which is leading to good results.

Reviewer 3:

The reviewer commented that the work appeared to be very seamless, but could not tell from the presentation who did what, so unfortunately could not comment on the collaboration execution.

Reviewer 4:

The reviewer mentioned that the project team collaboration involves many organizations and researchers, but an effective communication approach must be established.

Question 4: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer commented that the project team's proposed future work, the design of large format cells of high-energy with the incorporation of Si-anodes, is the right approach now that the project is reaching completion.

Reviewer 2:

The reviewer observed that the proposed future work on selecting final coating, as well as further detailed analytical work to disclose fundamental mechanisms, is well structured. From the previewed results, it is questionable whether further coating attempts, as described in the Future Work, will be successful, in particular as there is only little time left. The reviewer added that due to the remaining open questions, it seems critical to reach the project targets on cell level. It would be desirable to have more detailed action items on target cell level and a forecast of expected final performance.

Reviewer 3:

The reviewer commented that the project team's proposed future work needs to have some cost guidance put into the future research direction.

Reviewer 4:

The reviewer pointed out that the most significant challenge is to use Si material in this project, but most of the current work is focused to the cathode materials. The project teams need to set up a clear and specific plan for addressing anode materials.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer said that the work is very relevant to the overall DOE objectives. The development of high-energy batteries is at the core of the petroleum displacement objective.

Reviewer 2:

The reviewer stated that the high-capacity cell designs are an important piece of vehicle electrification.

Reviewer 3:

The reviewer observed that the work is aimed towards achieving a higher battery energy density necessary to increase the range and market chances for future PHEVs and EVs.

Reviewer 4:

The reviewer noted that enabling the use of the high-energy offered by Li-rich cathode material is essential for achievement of DOE objectives.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer acknowledged that the project team is almost at the end of the program, and based on the data and the amount of work performed, the resources were well utilized.

Reviewer 2:

The reviewer noted that the budget is not broken down for individual effort.

High-Energy, Long Cycle Life Lithium-Ion Batteries for PHEV Applications: Donghai Wang (Pennsylvania State University) - es212

Presenter

Donghai Wang, Pennsylvania State University.

Reviewer Sample Size

A total of four reviewers evaluated this project.

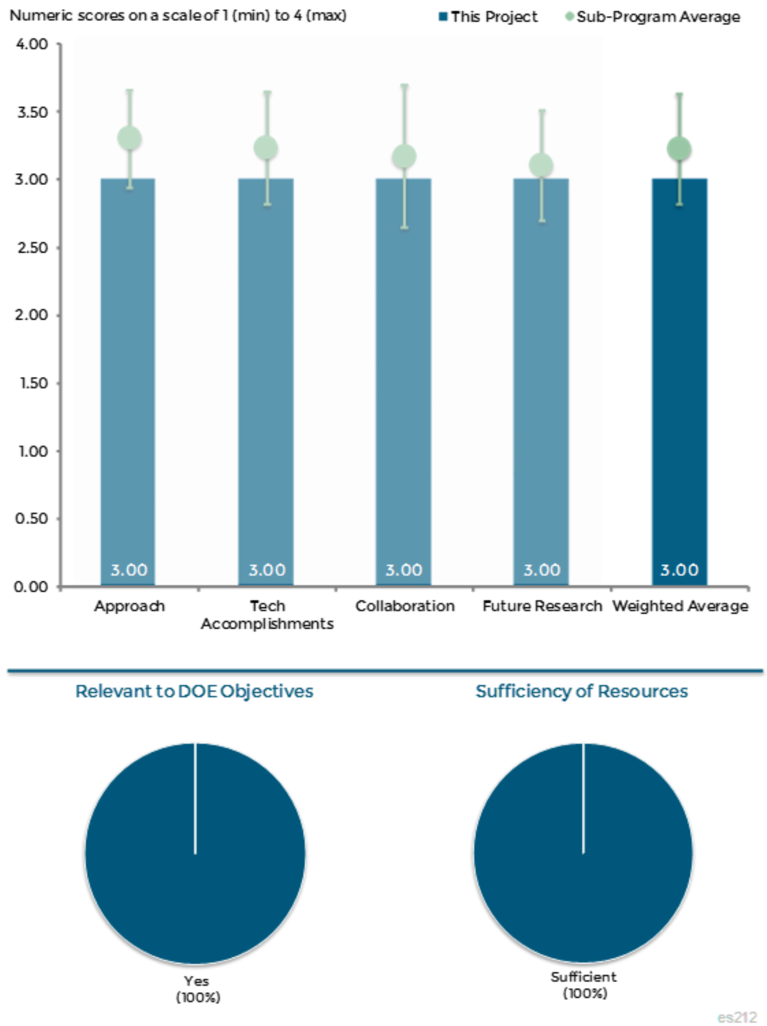


Figure 2-30 High-Energy, Long Cycle Life Lithium-Ion Batteries for PHEV Applications: Donghai Wang (Pennsylvania State University) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer explained that the technical approach shows a very good understanding to improve properties step-by-step towards the target. The path to the project cell is systematically planned.

Reviewer 2:

The reviewer stated that the author tried to focus in many different areas to produce a higher energy battery. The problem was attacked from multiple fronts, such as new energy cathodes, electrolytes, electrolyte additives, coatings, and Si/Si alloy-C electrodes.

Reviewer 3:

The reviewer stated that the work material is not a pure gradient cathode material but there is a possibility of mismatch between the phases leading to structural failure, and it is not clear about how to improve the performance by using Si/graphite anode. Pre-lithiation is a common approach, but it cannot solve all the problems.

Reviewer 4:

The reviewer commented that the organization of the discussion was difficult to follow, and wondered if the Si section appears to be evaluating Si particle options paired with a variety of carbon materials. The discussion then moved into some level of binder development, but it was not clear which Si carbon matrix had been chosen. The reviewer pointed out that the final structure was shown to have a modestly acceptable short term performance behavior but with a very high first cycle capacity loss, and it is not completely clear what the outcome of all of this was.

The cathode material development appeared to be moving toward the production of gradient designs, but it was not clear how they compared to previous design attempts. The reviewer added there was then some data presented on proprietary additive addition to the electrolyte for both cathode and anode performance enhancement, but there was no summarization of the results that could provide a reasonable summary.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer observed that the results on the pre-lithiation are very interesting and the work efficiently improves first cycle efficiency. This path should be further investigated, but the cycle stability of the Si anode materials investigated is still not sufficient to meet the target. Moreover, with 500 mAh/g and 3 mAh/cm^2 the capacity or loading are not outstanding, and thus, it indicates a limited Si amount in the anode for reasons not given. It is recommended to address the potential of the Si-C approach towards higher capacities and the interaction with cycle life.

The reviewer notes that the cathode material investigation of particle size is very interesting, but regarding the dependence on the cooling rate, a theoretical understanding of the experimentally seen effect should be elaborated on. The same is true for the concentration dependence of the lithium zirconate (Li_2ZrO_3) coating. The reviewer questioned why it is optimum at 3%. The high degradation of the material down to 100 mAh/g at C/3 discharge rate after 500 cycles is critical, and the recovery of the capacity at C/20 discharge rate may indicate that connection of particles are lost or have a high resistance, and it is recommended to look in detail on the effect causing this degradation. The reviewer mentioned that the electrolyte and additive work is also very interesting but it is difficult to judge whether one of the alternatives will meet the target of 500 cycles, for the results show only to about 50 cycles. It is recommended to narrow down to one or two candidates for the target cell and extend cycling.

Reviewer 2:

The reviewer stated that the author has made progress and work is in progress for the 250 watt-hour per kilogram (Wh/kg) and 330 Wh/kg batteries but noted that the Li_2ZrO_3 coating is not clearly explained, questioned if it was that done in a batch process, and expressed an interest to know if the process is scalable. For the gradient cathode powders, it will be very important to know how scalable that process is, for the project team mentioned that they have done some scale up experiments. The reviewer added that the authors have produced a variety of powder cathodes and pointed out that, at some point in the project, it will be important to know how reproducible is the synthetic method used for the production of those powders. Similarly, the complicated anode synthesis should be discussed in terms of consistency.

Reviewer 3:

The reviewer expressed that it was difficult to follow the approach and outcomes in a clear way.

Reviewer 4:

The reviewer said that the demonstrated cycle number is still far too low, less than 100, and the understanding and explanation for observed phenomena is not clear.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer said that the collaboration is well balanced, seems to work effectively, and is well coordinated.

Reviewer 2:

The reviewer expressed that there is good collaboration with other groups and institutions.

Reviewer 3:

The reviewer noted that the collaborators are listed but it was not clear in the data section who was doing what.

Reviewer 4:

The reviewer explained that detailed and specific collaboration activity is missing. All the collaboration starts with the team working, but the what and how are missing.

Question 4: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer explained that the future work is well described and addresses the key issues although it has to be questioned whether all listed open items can be investigated in detail within the short remaining time. The reviewer recommended prioritizing which action items give the highest output in a short time, and the highest benefit to approach the target on cell level.

Reviewer 2:

The reviewer commented that the author should probably down select one or two gradient powders for future studies, and some consideration to scalability of the different processes should be addressed in the future.

Reviewer 3:

The reviewer noted that the future work is a list of many things, but it should be oriented based on prior analysis for it is not just a laundry list.

Reviewer 4:

The reviewer commented this basic work is occurring in a number of the proposals being reviewed at this meeting. The reviewer assumed that a summit meeting specific to this area of development might help determine the most effective pathways to pursue.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that yes, high-energy batteries is what is needed to support the overall objective of petroleum replacement.

Reviewer 2:

The reviewer noted that high-capacity materials are critical to the DOE development pathway.

Reviewer 3:

The reviewer explained that the work is intended to develop a Li-ion battery system with high-energy density, high power density, good cycle life, and safe operation for EV applications, which is essential for the achievement of DOE objectives.

Reviewer 4:

The reviewer pointed out that the work is aimed towards achieving a higher battery energy density necessary to increase the range and market chances for future PHEVs and EVs.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer observed that the project is almost over at this point based on the amount of work reported and the data obtained, and it seems that the resources have been well allocated.

Reviewer 2:

The reviewer noted that a detailed budget plan for individual research efforts is not given.

High Energy Density Lithium-Ion Cells for EV's Based on Novel, High Voltage Cathode Material Systems: Keith Kepler (Farasis) - es213

Presenter

Michael Slater, Farasis.

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

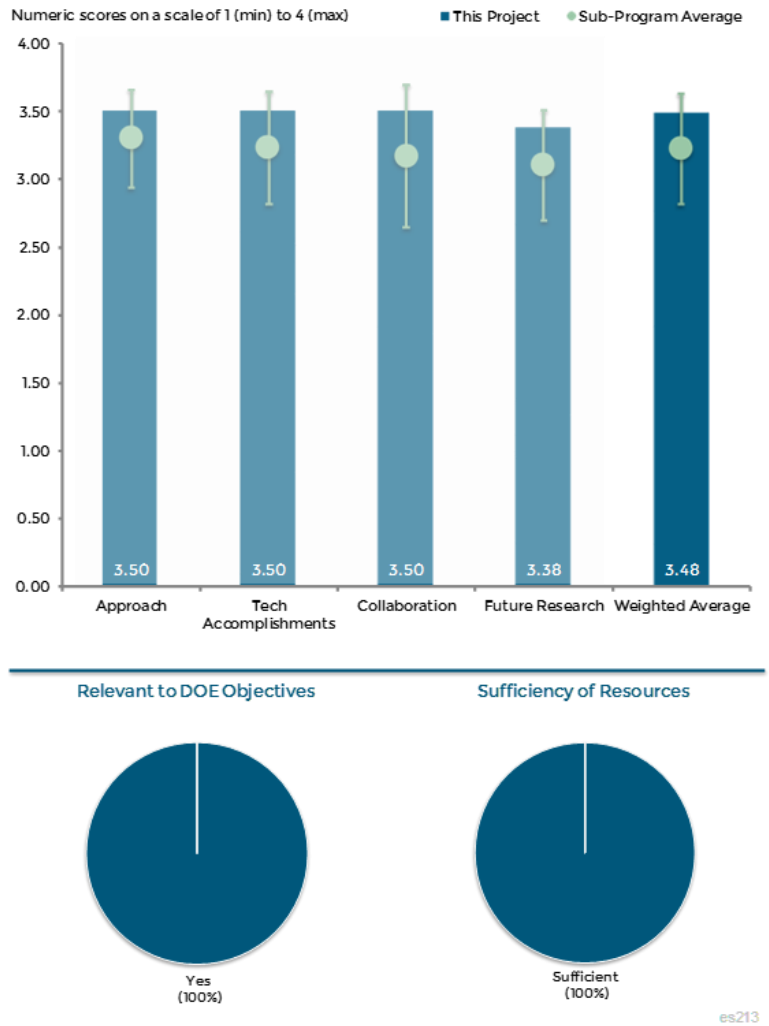


Figure 2-31 High Energy Density Lithium-Ion Cells for EV's Based on Novel, High Voltage Cathode Material Systems: Keith Kepler (Farasis) - Electrochemical Energy Storage

Reviewer 1:

The reviewer stated that the authors are sharply focused in critical areas and are trying different approaches in parallel. Although the ion-exchange approach is adding additional complexity and cost, the authors are aware of it and have planned on tackling the issue with a productive, high-volume operation.

Reviewer 2:

The reviewer affirmed that the proposed approach is comprehensive and promising, but it seems to be focused on energy, where an idea and evaluation for rate performance improvement are also needed. The presentation slides must also be updated from the last year based on new results, as most of the slides are same as the previous one.

Reviewer 3:

The reviewer noted that the project team certainly has a very comprehensive approach that attempts to move every significant component in a cell towards a higher performance. It might be difficult to assess whether each effort is best-of-breed, but still is an ambitious effort.

Reviewer 4:

The reviewer commented that the project team’s technical approach is reasonable as where the ion-exchange materials might be a suitable way to reduce the stability problems of the layered-layered material. In particular, it is appreciated that on the cathode material side, both material candidates, layered-layered and Ni-rich NMC, are investigated, which gives the opportunity of a fair comparison and the choice of the better material at the end. The reviewer added that on the anode side, this strategy is not followed, but it is focused on only one development route that has even lower scientific support. That route might be a small weakness.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:
The reviewer observed that the amount of work has been significant with the efforts on high-voltage electrolyte, Si containing anodes, evaluation of multiple coatings for the nickel cobalt manganese (NCM) powders used in the Gen-1 cell. The coating approach on NCM powders seems to be very effective.

Reviewer 2:
The reviewer stated that the progress had some very interesting results in a number of technical fronts. Coated cathodes and advanced electrolytes in particular showed interesting improvement options, and the Si anode development follows most of the efforts seen in this year’s round of updates, where cycle fade remains an issue and little fundamental understanding about its origins seems to exist.

Reviewer 3:
The reviewer explained that the progress on both cathode material approaches is substantial as also shown in es257 with full cell testing showed reasonable progress and results. Little was reported on the Si-C anode development. It is recommended to intensify the work on this part. In particular, 8% Si content and below 600 mAh/g the cycle life is quite poor and even less acceptable at 1000 mAh/g. The reviewer added that the electrolytes are difficult to judge as there is no information given regarding the changes leading to the improved cycling. Moreover, the target for the high-voltage (HV) electrolyte development is stated to be 4.7 V, but the cycle improvement is only shown at 4.4 V. The reviewer noted that the same is true for the cathode material where capacity measurements where shown at 4.6 or 4.7 V, but the cycling results only at 4.4 V. It is not clear which voltage is needed to meet the targets. The reviewer concluded that it is recommended to harmonize the test condition in the subprojects and set the specifications to the target values.

Reviewer 4:
The reviewer noted that the rate capability must be examined with different C rates.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer stated that the project team has very good collaboration with different groups and institutions.

Reviewer 2:
The reviewer observed that the project team’s number of high powered collaborators seem to be working well together, and integrated cell builds with various developed components seems to be moving appropriately.

Reviewer 3:
The reviewer expressed that the project team’s collaboration it is well developed and has specific duties for each organization.

Reviewer 4:
The reviewer commented that there are four competent and experienced partners, and the group has the necessary capabilities and the right size to work as a well-coordinated and effective team. On the Si based anode material development, the cooperation could have been strengthened, for example, by an institute providing more detailed analyses or a second material source.

Question 4: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer stated that the project team has performed a good effort with good focus on the future goals and execution strategy.

Reviewer 2:
The reviewer observed that the proposed future work is following the initial approach in a suitable and structured way.

Reviewer 3:
The reviewer noted that analysis and evaluation for rate performance and aging must be added.

Reviewer 4:
The reviewer opined that a careful selection of the optimized treatments in each area including anode, cathode, coatings, and electrolytes, is going to be critical, where reproducibility of the results is going to be very important. These are not very standard processes, and even the scale up of the cathode powder should be carefully tested.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer remarked that yes, the project is very relevant for the very important objective of petroleum displacement.

Reviewer 2:
The reviewer concluded that higher energy density cells are a critical component of vehicle electrification.

Reviewer 3:
The reviewer pointed out that the work is aimed towards achieving a higher battery energy density necessary to increase the range and market chances for future PHEVs and EVs.

Reviewer 4:
The reviewer stated that the new cathode and anode electrode materials and Li-ion cell components are required to enable the DOE objectives.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer acknowledged that the project is almost complete and that the resources were well utilized.

Reviewer 2:
The reviewer commented that the project team has a lot of resources, which seem to all be contributing to the project appropriately and effectively.

Reviewer 3:
The reviewer noted that the detailed budget activity is not provided.

First Principles Modeling of SEI Formation on Bare and Surface/Additive Modified Silicon Anodes: Perla Balbuena (Texas A&M University) - es214

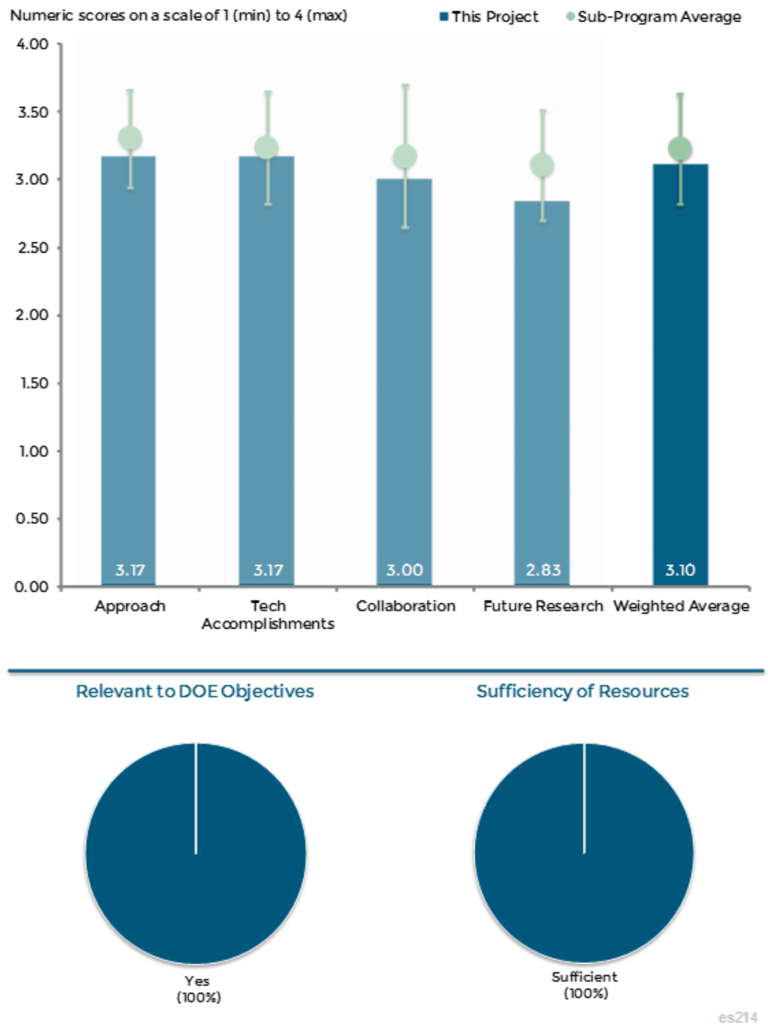


Figure 2-32 First Principles Modeling of SEI Formation on Bare and Surface/Additive Modified Silicon Anodes: Perla Balbuena (Texas A&M University) - Electrochemical Energy Storage

Presenter

Perla Balbuena, Texas A&M University.

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer explained that this simulation work revealed many details of SEI formation on Si electrodes including lithiated Si, silicon dioxide (SiO2) covered Si, and ALD coated Si. The approach compliments well with several other Annual Merit Review (AMR) projects.

Reviewer 2:

The reviewer stated that the First Principles quantum mechanical modeling should yield quantitative results and predictions, but the slides for and the Principal Investigator’s (PI's) presentation at the AMR were largely qualitative. Furthermore, it was unclear whether any statistical data analysis was performed to ascertain the conclusions based on numerical calculations and simulations. The reviewer added that it was also unclear how sensitive the results are dependent on the initial conditions and configurations. For example, it is hard to believe that the hydroxylated amorphous film, $Li_xSiO_{2.48}H_{0.9}$, as shown on Slide 7, exists only at this particular composition. The reviewer asked whether the results presented on Slide 8 are statistically significant and independent of initial configurations. Regarding Slide 12, the reviewer asked what “many” refers to in the sentence, “EC/FEC in many cases reduce before LiPF6.” The reviewer inquired about identifying the other cases that also occur and how often. Finally, this reviewer requested clarification on what would be a reasonable agreement as shown on Slide 18, and on what standard deviation the conclusion is based.

Reviewer 3:

The reviewer explained that any Li-ion electrode SEI represents an extremely challenging problem to tackle with calculations of first principles, and the difficulties and benefits associated with the Si electrode makes this work even more challenging and very pertinent. While the reviewer admits not being the best judge of this type of work, the reviewer was impressed with the breadth of the PI's approach. It seemed that the PI is trying to address all aspects of the problem.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer observed that the PI has shown many interesting results, but it is difficult to assess the true impact of the PI's calculations and to be sure how to build on the PI's conclusions. The PI also favors the impact of fluorinated ethylene carbonate (FEC) to that of vinylene carbonate (VC), but they have a very different effect on cycling.

Reviewer 2:

The reviewer remarked that progress was made in many areas. The reviewer had two questions. First, the reviewer noted that hydrofluoric Acid (HF) is known to accelerate many degradation reactions. The reviewer asked will HF be formed due to FEC dissociation as fluorine (F) is generated. Second, it is not clear why it is claimed that ethylene carbonate (EC) leads to uncontrolled SEI growth. The reviewer added that, furthermore, more connection with experiments can be made.

Reviewer 3:

The reviewer explained that the first principles of quantum mechanical modeling should yield quantitative results and predictions, but the results presented are qualitative without the support of detailed statistical analysis and sensitivity analysis of initial conditions. The quality of the slides should be improved. For example, there was a grammatical error on Slide 6 and missing horizontal and vertical axis labels on Slide 16.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that the PI has a number of collaborations with other modelers and researchers examining the complex material and associated SEI.

Reviewer 2:

The reviewer expressed that more collaboration with SEI property characterization and modeling work will be fruitful to the project team.

Reviewer 3:

The reviewer pointed out that collaborations with experimentalists at University of Rhode Island and NREL have not produced quantitative comparisons between theory and experiments. Also, it is unclear whether the modeling effects have produced quantitative predications to guide experiments.

Question 4: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer looks forward to seeing the overall conclusions of this work and the benefits to Si electrode development.

Reviewer 2:

The reviewer observed that because the microscopic models are not sufficiently quantitative and predictive, it is unclear how the microscopic models can be used to effectively develop mesoscopic models.

Reviewer 3:

The reviewer wondered if there are any suggestions on new additives and solvent molecules that should be tested in future work.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer explained that this project will lead to improved high-energy electrode materials, which should reduce costs and enable further electrification of the nation's vehicles and result in improved gas mileage.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer noted that the PI is effectively using the available funds.

Analysis of Film Formation Chemistry on Silicon Anodes by Advanced In Situ and Operando Vibrational Spectroscopy: G. Somorjai (University of California, Berkeley) - es215

Presenter

G. Somorjai, University of California, Berkeley.

Reviewer Sample Size

A total of three reviewers evaluated this project.

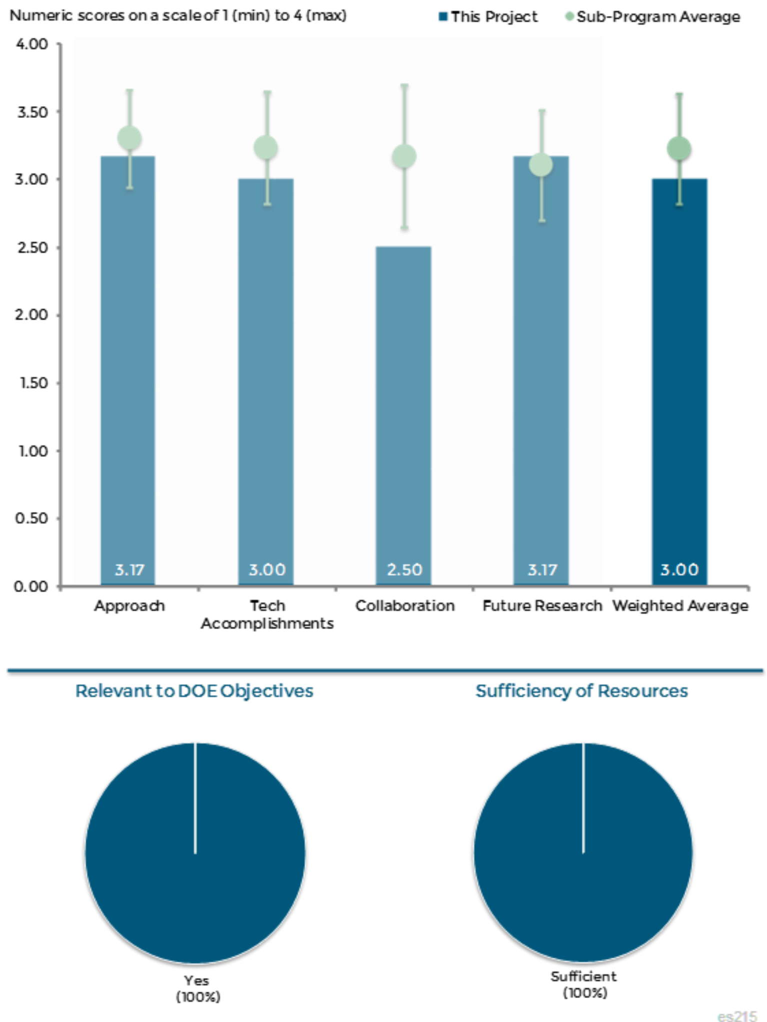


Figure 2-33 Analysis of Film Formation Chemistry on Silicon Anodes by Advanced In Situ and Operando Vibrational Spectroscopy: G. Somorjai (University of California, Berkeley) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer praised that the project team has a wonderful approach for attempting to elucidate the composition and structure of SEIs on Si and other surfaces.

Reviewer 2:

The reviewer explained that the PI aims to investigate SEI on the Si surface using in-situ operando (FGVC and Fourier transform infrared spectroscopy (FTIR) in combination with ex-situ X-Ray photoelectron spectroscopy (XPS), scanning electron microscope (SEM) and transmission electron microscope (TEM). This is a powerful but rather common approach, and the use of more advanced complimentary techniques such as time-of-flight secondary ion mass spectrometry (TOF)-(SIMS), depth-profile XPS, and synchrotron spectroscopy, etc., would make the project stronger.

Reviewer 3:

The reviewer stated that the PIs applied in-situ and operando vibrational spectroscopies to directly monitor the composition and structure of electrolyte reduction compounds formed on the Si anodes. The key issue for SEI on Si is the mechanical property and electronic and/or ionic conductivity.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer expressed a confusion as to why the fundamental components of the SEI would be different on Si verses on graphite but noted an understanding of why those chemical species would bond differently on Si versus graphite, and perhaps could be different if, say O on Si, contributed to the reaction and resulted in different species being formed. It is excellent that team is investigating the impact of FEC and VC additives on SEI formation, and also impressive that with the time dependence of the SEI layer, the team showing that it grows, and thus, not passivating it for quite a long time.

Reviewer 2:

The reviewer observed that the PIs just tested the SEI composition on Si and graphite, but noted that it was not clear why the composition of SEI on Si is different from the SEI composition on graphite.

Reviewer 3:

The reviewer noticed that the findings of the PI related to VC and FEC are mostly consistent with other researchers in the field and thus, are not uniquely insightful. Other novel claims are on the formation of soluble organic compounds on Si surface such as Li propionate and diethyl 2,5 dioxohexane dicarboxylate verses formation of insoluble compounds on graphite surface, in DEC:EC mixture, which are novel but hard to believe based on prior experience and previous reports. The reviewer added that no experimental evidence was presented during the presentation, whereas in other prior studies, washing Si SEI formed in DEC:EC by DEC or DEC:EC mixtures have been reported not to dissolve the SEI. Thus, claims on the soluble organic components of the SEI are slightly hard to believe because no clear explanation was given on the impact of Si surface on the composition of the organic SEI components.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that a few collaborators have been identified.

Reviewer 2:

The reviewer noted that the PIs did not list the collaborators.

Reviewer 3:

The reviewer remarked that very little information was given on interactions and collaborations with other groups. Given the critical importance of this diagnostics and how many people are interested in the results, it might be valuable to the extent of the collaborations and to some of the many groups trying to use Si in Li-ion cells.

Question 4: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer fully supported the continued work on Si surface and the new work on high voltage cathodes. Perhaps collaboration with Kostecki on Mn reactivity in high-voltage cells would be valuable.

Reviewer 2:

The reviewer explained that while some of the future studies could be logical, even without listening to the presentation, the project team was not clearly justified in their talk. Conducting studies to answer many questions that still remain unclear, in regards to DOE, does not seem to be planned work, for example, why other researchers have not observed soluble SEI on Si, the mechanisms on the SEI differences, etc.

Reviewer 3:

The reviewer said that the PIs failed to provide details on future work.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer said that the investigation of SEI on anodes and cathodes is important for development of EV batteries.

Reviewer 2:

The reviewer stated that gaining a better understanding of the Si SEI may allow one to utilize Si based anodes in the future, which will reduce the cost of Li batteries and contribute to more widespread use of EVs.

Reviewer 3:

The reviewer explained that one of the issues with all of these Si projects (this is not a criticism of this project at all) is that they mainly seem to be working independently of one another. The reviewer would be interested to see a single lead try to integrate the results from this group, from Kostecki, from multiple developers, from universities, etc., into a single coherent picture so that it is clear what answers we have and what questions still need to be attacked. The reviewer suspected that the leading PIs in this field already understand this, but such an effort would probably be extremely valuable to DOE program managers.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer noted that the project funding level is good.

Reviewer 2:

The reviewer mentioned that the PIs have the equipment for the research, and should work with other modelling people and other PIs in the AMR who are working on the same topic.

Optimization of Ion Transport in High-Energy Composite Cathodes: Shirley Meng (University of California, San Diego) - es216

Presenter

Shirley Meng, University of California, San Diego.

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

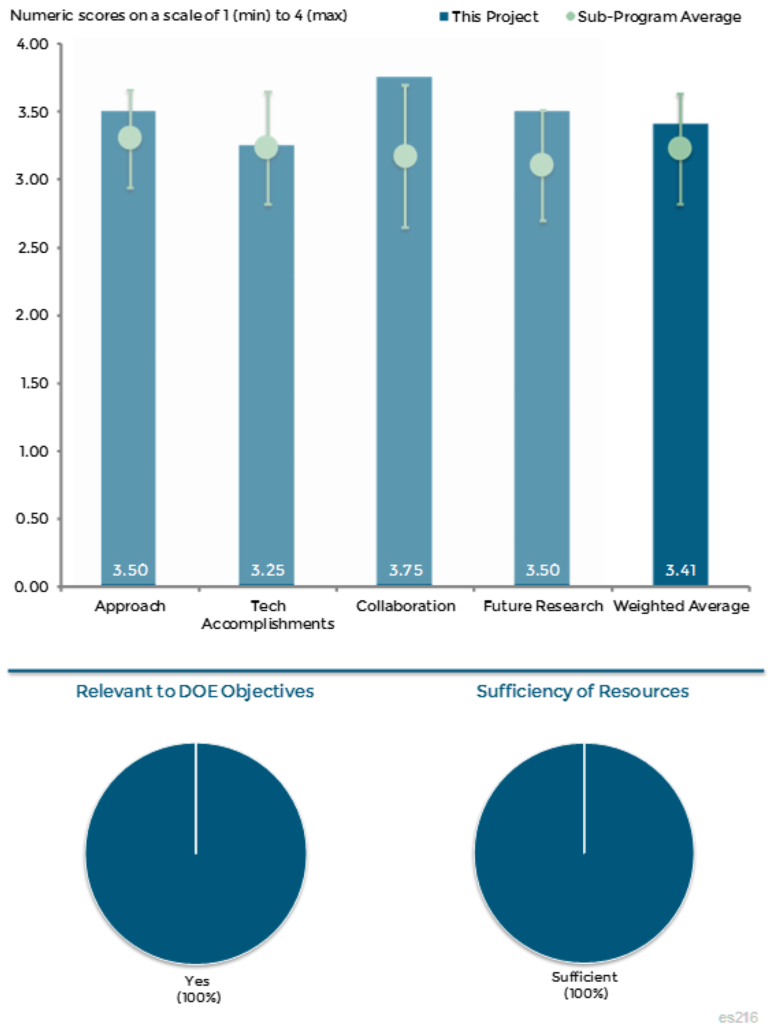


Figure 2-34 Optimization of Ion Transport in High-Energy Composite Cathodes: Shirley Meng (University of California, San Diego) - Electrochemical Energy Storage

Reviewer 1:

The reviewer pointed out that the PI of this project proposed a rather ambitious approach to address essentially almost all critical issues that face the high-energy battery chemistries, which include the capacity and voltage degradation of cathode, and the volume and SEI deterioration of Si. Based on the PI’s knowledge of function point (FP) calculation and spectroscopic characterization tools, the PI designed an encompassing tool suite that was used to also peer into the surface in the bulk of these materials and attempted to establish the work rationales. The reviewer added that these diversified means of spectroscopic and the methodology established in this project will certainly benefit the entire community.

Reviewer 2:

The reviewer observed that like Dr. Grey and Dr. Kostecki, this researcher is focused on the questions and barriers impeding the success of high-energy cells, and brings multiple diagnostics techniques to bear in order to understand the materials and their failure modes.

Reviewer 3:

The reviewer stated that the fundamental study on the mechanism for low-voltage stability of high-capacity cathodes and the low first-cycle inefficiency of Si is needed to be addressed.

Reviewer 4:

The reviewer described that the atomistic modeling combined with a scanning transmission electron microscopy (STEM or a-STEM), electron energy loss spectroscopy (EELS), X-ray photoelectron spectroscopy (XPS) and neutron diffraction (ND) were used to understand the dynamic change in the bulk and surface of electrodes. The researchers need to elaborate what is unique to their approach compared to other methods, such as X-ray absorption near edge structure (XANES) and extended X-ray absorption fine structure (EXAFS), and the Operando high-resolution transmission electron microscopy (HRTEM), and also need to clarify what knowledge can be obtained with their approach but cannot be acquired with other methods.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer noted that in the second year of this project, the PI has demonstrated a cathode capable of delivering greater than 300 mAh/g with decent cycling stability, where voltage-fading of lithium manganese rich (LMR) was also shown to be mitigated through morphology control rather than surface coating; however, the 80 cycle is still not convincing enough to claim to be effective, although the results are encouraging. The section of SEI chemical composition on the Si anode is less impressive than the cathode work, as similar results have been described in literature a few years back, but the newly established methodology is expected to reveal new perspectives. The reviewer added that the use of neutron characterization is especially innovative, which differentiates the distribution of Li from Li-layer and TM-layer, and thus, will help further understand why the Li-excess cathode material fades in long-term cycling and provide guidelines for designing future materials. This reviewer expressed that more new info will become available if the PI continues to exploit this technique, and perhaps, an improvement in pouch cell design could help.

Reviewer 2:

The reviewer stated that the accomplishments include a large number of excellent results, but expressed the need to point out that the voltage stabilization claimed on Slide 7 looks highly doubtful. The voltage on charge increases on the curve on the right, meaning that the voltage change is at least partly the result of impedance rise, and thus, must be removed from the data to understand the true voltage decay with cycling. The reviewer added that it would also be valuable to understand why this researcher thinks that surface modification is impacting voltage fade when ANL's exhaustive study last year found that it did not. The reviewer mentioned that the cathode SEI work was impressive.

Reviewer 3:

The reviewer expressed the need to clarify the mechanism of why the surface modification can improve the voltage stability. The reviewer asked how does the lithiation/delithiation mechanism of high-capacity cathode obtained from Operando neutron relate to the voltage decay. The reviewer asked why the thick SEI formed on Si from FEC-electrolyte has a more stable cycle life. The mechanical property of SEI may be more important for Si.

Reviewer 4:

The reviewer explained that the Li-ion de-intercalation activities of Li-excess were investigated by the Operando neutron scattering technique. The solid-electrolyte interphase, or SEI, composition in Si-based anode materials was measured, and the fluoroethylene carbonate, or FEC, co-solvent and other additives were found to promote the formation of a stable SEI. The reviewer expressed that the research team needs to clarify what new insight into the cathode evolution mechanism can be provided based on the characterization results, and added that it would be great if the research team can identify the critical factors that govern the formation of SEI.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer commented that the number and breadth of the collaborators is impressive and excellent which includes universities, national laboratories, and battery developers, and that the Si SEI results are excellent. The reviewer encouraged someone to review and integrate the multiple findings on this critical topic and to communicate an overall understanding of current SOA and what is known.

Reviewer 2:
The reviewer pointed out that the PI showed an excellent record of collaboration and coordination with other institutions.

Reviewer 3:
The reviewer stated that the PI has built a nationwide network to perform the collaborative research.

Reviewer 4:
The reviewer noted that the PI has collaborated with several groups on the Battery Materials Research (BMR) team.

Question 4: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer remarked that it is excellent that the PI is focusing on the impact of FEC on the Si SEI.

Reviewer 2:
The reviewer said that the objective proposed for future research is aligned very well with what DOE is focusing on.

Reviewer 3:
The reviewer noted that the PI plans to study the chemical stability of SEI upon cycling, but asked about any plans to study the mechanical property of SEI.

Reviewer 4:
The reviewer observed that several important issues will be addressed in the future, but suggested that the future work to be focused on the evolution of the interface between the electrode and the electrolyte, where an emphasis is placed on the clarifying the underlying mechanism of SEI and on identifying the critical factors that govern the formation of SEI. Furthermore, the reviewer commented that the rationale for developing the strategy for prevention of SEI formation should be addressed.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer stated that the ongoing research is well aligned with the mission and the objective of the DOE program.

Reviewer 2:
The reviewer noted that this project supports the DOE objective.

Reviewer 3:
The reviewer stated that yes, the project supports the DOE objective for obvious reasons.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer stated that the resources are sufficient for the work, but would support further funding if it were requested.

Reviewer 2:

The reviewer noted that the resources are sufficient.

Reviewer 3:

The reviewer mentioned that the PI should also add modelling components to explain the results.

Daikin Advanced Lithium-Ion Battery Technology - High-voltage Electrolyte: Ron Hendershot (Daikin America) - es217

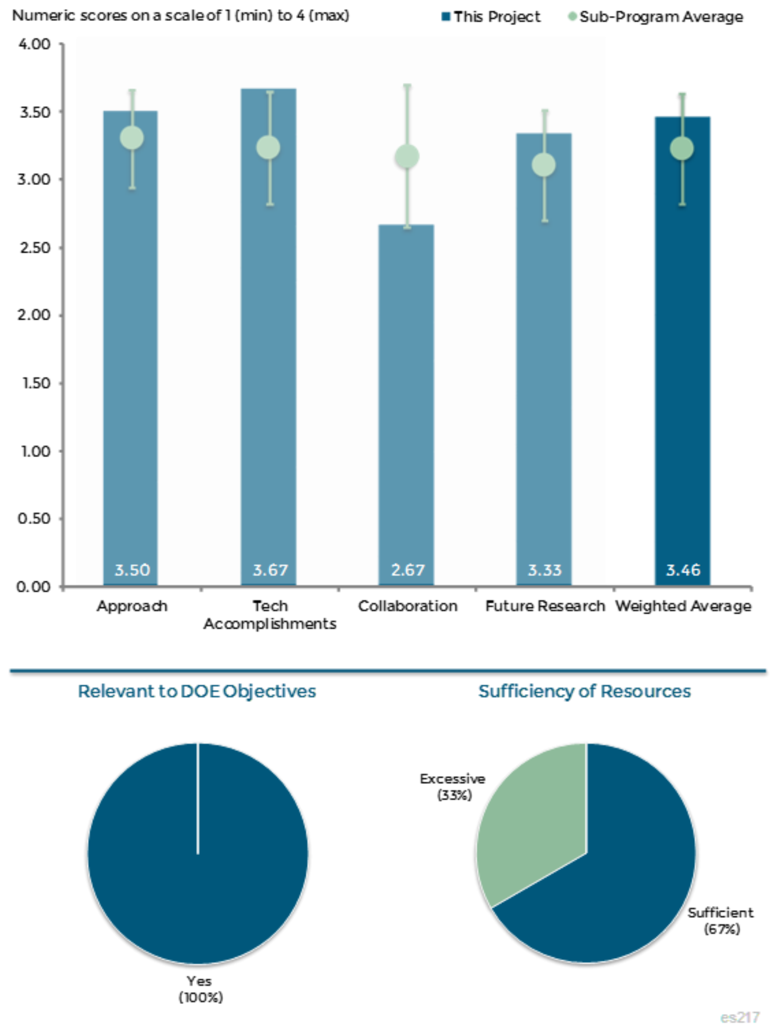


Figure 2-35 Daikin Advanced Lithium-Ion Battery Technology - High-voltage Electrolyte: Ron Hendershot (Daikin America) - Electrochemical Energy Storage

Presenter

Joe Sunstrom, Daikin America.

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer noted that the proposed fluorocarbon (FC) electrolyte should be effective in improving the cycle life at 4.6 V and in improving the safety performance.

Reviewer 2:

The reviewer commented that it seems that the authors have been working in areas that are critical to the objective of the program, and at some point, it should be of interest to compare the data obtained with Li NCM 111 (1/3, 1/3, 1/3) with a cathode containing higher Ni content. In the future it will be important to better understand the mechanism involved with the increased gassing as the FEC content is increased.

Reviewer 3:

The reviewer described that the PI adopted a typical industrial research and development (R&D) approach for new product development from benchmarking, selection and optimization. However, without details of the process, it is hard for the reviewer to further comment on the matter.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer described that the PI demonstrated the significant improvements of FC electrolyte composition that out-perform the traditional hydrocarbon electrolyte at high-voltage cells. Such improvements included cycle-ability and safety. The reviewer also noted that the milestones were all reached.

Reviewer 2:

The reviewer commented that seems that the authors are on the right track for this month, the team is demonstrating stable cell performance at 4.6 V, and last January, the authors delivered 10 interim cells to DOE.

Reviewer 3:

The reviewer stated that the FC electrolyte was shown to be effective in improving the cycle life, especially at elevated temperatures. The FC electrolyte also improved the overcharge safety performance. However, it was not clear why the FC electrolyte was not effective in improving the calendar life at 4.6 V. The reviewer added that the FEC additive was demonstrated to be effective on anodes such as Si, and thus, it was not clear how FEC also provided enhancement for the high-voltage cathode and electrolyte interface.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted that the extent of collaboration with Coulometrics was not clear.

Reviewer 2:

The reviewer commented that the team's collaboration could be improved. The authors mentioned that in the last part of the project, which involve surface characterization, will be pursued outside the company.

Reviewer 3:

The reviewer stated that the PI still lacks collaboration with other institutions, although the project team realized the significance of the matter.

Question 4: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer observed that the proposed future research is well described and reasonable. The PIs should extend the fundamental understanding of the FC electrolyte and preferably collaborate with either national laboratories or universities.

Reviewer 2:

The reviewer commented that some consideration should be given to the scalability of the process discussed, and in particular, to the synthetic work related to the electrolytes.

Reviewer 3:

The reviewer remarked that the project team needs to propose some future effort to de-conflict the results between cycle life verses calendar life gassing results, and should also propose effort to understand how FEC enhanced high-voltage cathode. The insight from understanding the mechanism will help to discover other additives for high-voltage cathodes.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer commented that developing an electrolyte that can work at high-voltage effectively and safely is relevant to the goal of developing high-energy density batteries for EVs.

Reviewer 2:

The reviewer said that yes, electrolytes for high-voltage applications are badly needed for high-energy density cells.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer pointed out that the PI has adequate resources for the proposed research and is achieving the milestone and goals.

Reviewer 2:

The reviewer noted that the project is finishing this year and it seems that the authors have produced a reasonable amount of data based on the funding.

Fluorinated Electrolyte for 5 V Lithium-Ion Chemistry: John Zhang (Argonne National Laboratory) - es218

Presenter

John Zhang, Argonne National Laboratory.

Reviewer Sample Size

A total of three reviewers evaluated this project.

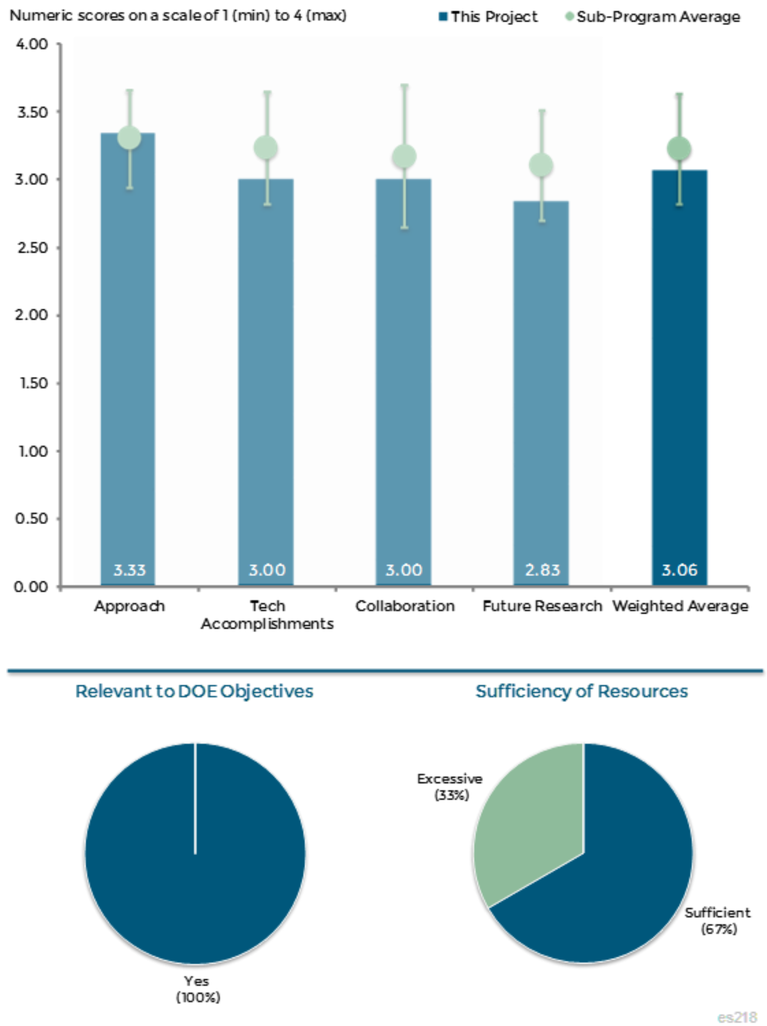


Figure 2-36 Fluorinated Electrolyte for 5 V Lithium-Ion Chemistry: John Zhang (Argonne National Laboratory) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that the work effort has been much focused on the barriers and imagines that the synthetic efforts are not easy, but has a very nice contribution from the theoretical area.

Reviewer 2:

The reviewer said that the PIs try to synthesize fluorinated electrolyte guided by theoretical calculation. Although the approach of using the highest occupied molecular orbital (HOMO) and the lowest occupied molecular orbital (LOMO) only is over-simplified, it is a good starting point, and the chemical synthesis is the strong point of approach.

Reviewer 3:

The reviewer observed that the approach is similar to that in 2014 where the project team proposed to expand the electrochemical window by introducing cathode additive and new solvents. These general approaches should be effective to mitigate the low electrolyte oxidation barrier, cycle life barrier, high- and low-temperature barrier, and the safety barrier.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer noted that the progress is sharply focused on the critical areas. At some point in the future, the authors should focus also in how scalable some of the synthetic efforts are.

Reviewer 2:

The reviewer explained that various fluorinated electrolytes were synthesized and tested in the cells. Even though the chemical synthesis was the bright side of the project, the technical accomplishments on the characterization were weak, especially, for example, the in-depth understanding of the electrolyte working in a cell interaction with electrodes. The reviewer added that it is interesting that most of the peer-reviewed publication was co-authored with a senior researcher who is not on the team, and also realized that the PI did not include the response to the reviewer's comments from last year.

Reviewer 3:

The reviewer stated that in the ANL section of the presentation, most of the slides seemed to be similar to that of 2014, where most of the cycle life improvement data was based on only single-cell and 50-100 cycles. To be impactful, the project team needs to show cycle life based on multiple cells and at least 300 cycles on the optimized electrolyte. The reviewer added that in order to demonstrate that the electrolyte will meet PHEV or EV needs, the team needs to demonstrate that their electrolytes improve high-temperature stability without compromising low-temperature performance. There is limited performance data from additives from the synthesis of which was presented in 2014, and thus, the reviewer expressed an expectation to see more performance data in 2015, for the team needs to link the chosen additives to their proposed approach rationale. The reviewer expressed, for example, if the room temperature (RT) and 55°C cycle life improvement from FEC, TF-PC3 and lithium difluoro-oxalato-borate (LiDFOB) additives be attributed to the cathode/electrolyte interface, and if so, how these additives improved the cathode and electrolyte interface. There is lack of continuity from the 2014 effort. The reviewer also expressed if there is the follow-up on the good results of the E3, E4, E5, E6 and high voltage electrolye-1 (HVE1) electrolytes presented in 2014, and if there a synergistic effect to combine the aforementioned additives with high voltage electrolye-3 (HVE3).

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that there seems to be strong collaboration. The marriage between theory and organic synthesis is very interesting. The data related with the non-flammable fluorinated electrolyte was impressive.

Reviewer 2:

The reviewer stated that the PI and co-PI of the U.S. Army Research Laboratory (ARL) demonstrated close collaboration, but the collaboration with others were not evident.

Reviewer 3:

The reviewer observed good collaboration with ARL. The extent of collaboration with the other performers was not clear.

Question 4: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer pointed out that the project is finishing this year, and that the electrode surface analysis can prove to be important. The authors should probably try to down select the synthetic work that has higher chances of success going forward, and that the synthetic efforts in research and development should also, at some point, be related to some practical considerations such as scalability.

Reviewer 2:

The reviewer noted that the proposed future research is reasonable, but should include a more fundamental understanding of the work.

Reviewer 3:

The reviewer stated that the project team needs to propose some future effort to address the low-temperature performance without sacrificing performance at high temperatures. The team also needs to propose a future effort to improve calendar life and to give a rationale on why the team proposed to pursue the sulfone-based electrolyte. It was not clear why the team did not propose to combine the fluorinated solvents with the additives for future effort.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer remarked that yes, more stable electrolytes for high-voltage and less flammable applications are critical for the development of high-energy batteries.

Reviewer 2:

The reviewer noted that the proposed research is relevant to the DOE goal for high-energy Li-ion battery development.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer observed that the project is reaching completion this year. The authors have put together a tremendous synthetic effort, and thus, the resources were well invested.

Reviewer 2:

The reviewer noted that the PIs have access of more than adequate resources for the research.

Novel Non-Carbonate Based Electrolytes for Silicon Anodes: Dee Strand (Wildcat Discovery) - es219

Presenter

Dee Strand, Wildcat Discovery.

Reviewer Sample Size

A total of three reviewers evaluated this project.

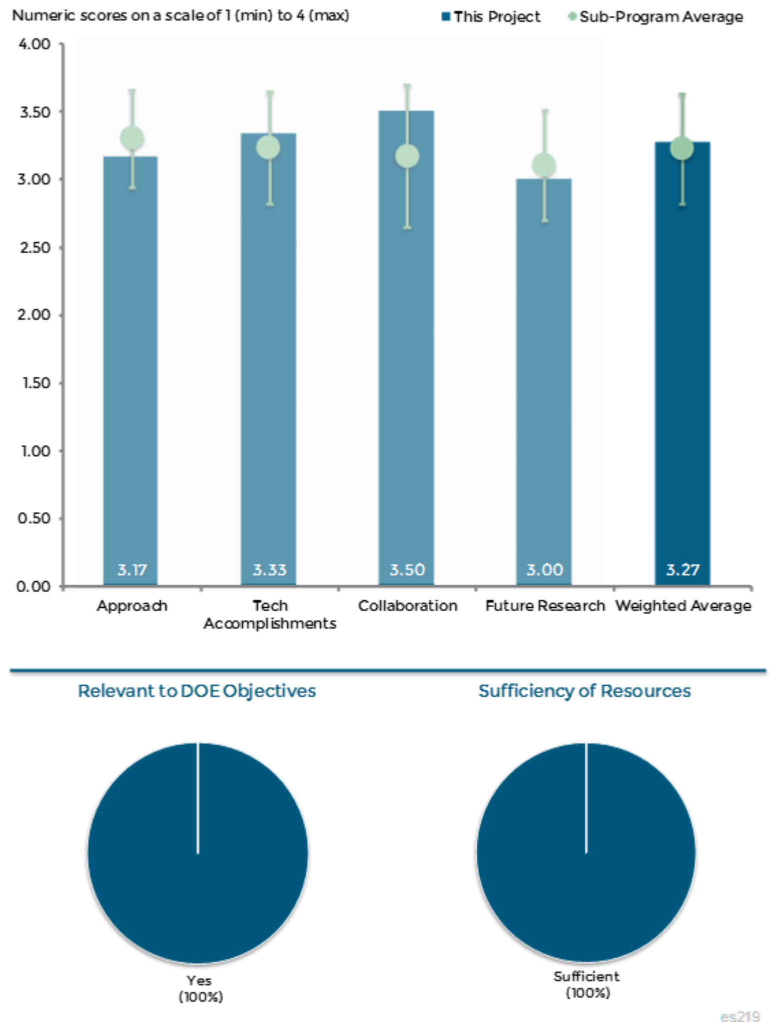


Figure 2-37 Novel Non-Carbonate Based Electrolytes for Silicon Anodes: Dee Strand (Wildcat Discovery) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commented that the approach is very focused on the development of non-carbonate electrolyte for the Si alloy anode, which is a very complex problem because as the standard electrolyte is replaced, new additives and salts have to be developed.

Reviewer 2:

The reviewer stated that the PI used high throughput techniques to screen large amount of non-carbonate electrolytes for Si anode. Although such an approach is effective for fast screening, the PI should either engage fundamental research so the screening can be more focused, or develop a feasible statistical method to analyze the large amount of data points.

Reviewer 3:

The reviewer explained that Si-stable additives and non-carbonate solvents were proposed for an optimized electrolyte that is stable with Si anode, and expressed that is not clear how non-carbonate solvents combined with the additive will form more stable SEI than carbonate solvents combined with the additive. The project team needs to provide their rationale for selecting the non-carbonate solvents that are stable with Si alloy anode, and the additives that will form SEI in the absence of EC.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer reported that it seems that the authors have accomplished greater than 200 cycles to 80% capacity with non-carbonate formulations, but could be of great interest to know if 500 cycles are finally achieved. At some point, the authors should give more detail about the type of NMC cathode that the team is using. The reviewer added that ideally, the electrolyte should to be stable towards a variety of cathode powders.

Reviewer 2:

The reviewer observed that the milestones were achieved. Although a large amount of electrolytes were tested, the reviewer questioned the statistical significance of the results, for example, how reliable the conclusion is and what the team's confidence level is.

Reviewer 3:

The reviewer commented that there was not much meaningful data presented that allow the progress to be assessed, where the most significant data presented was the specific capacity verses cycle number plot. There was no data on rate capability, voltage stability window, and initial irreversible capacity loss of the optimized electrolyte in a NMC/Si cell. The reviewer added that in the absence of this data, it is difficult to assess if the team's optimized electrolyte will improve the energy density of a Li-ion cell based on Si alloy anode, especially when the team attributed the low-capacity in 18650 cells to a non-optimized design.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that the project team seems to have very good collaboration with 3M Company and ANL.

Reviewer 2:

The reviewer noted that the PI collaborates with many other institutions indeed.

Reviewer 3:

The reviewer said that the project team has adequate collaboration with ANL and 3M Company, though it was not clear the extent of data sharing.

Question 4: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer explained that additional testing on other Si sources is recommended as already mentioned by the authors, where high-voltage stability and large cell format were already mentioned.

Reviewer 2:

The reviewer noted that the statistical approach should be added to the future research.

Reviewer 3:

The reviewer said that the proposed future work was very vague. The project is only 68% completed, and thus, the project team should be more specific on what future work and why, for example, what additives combinations and why.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer remarked that yes, the project is very relevant to petroleum displacement. High-capacity Si anodes is one of the areas that can increase the energy density of a battery.

Reviewer 2:

The reviewer said that the development of non-carbonate electrolyte for Si anode is relevant to the goal of developing high-energy density batteries.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer observed that the project is finishing this year and that the authors got a lot of work done with the resources allocated.

Predicting Microstructure and Performance for Optimal Cell Fabrication: Dean Wheeler (Brigham Young University) - es220

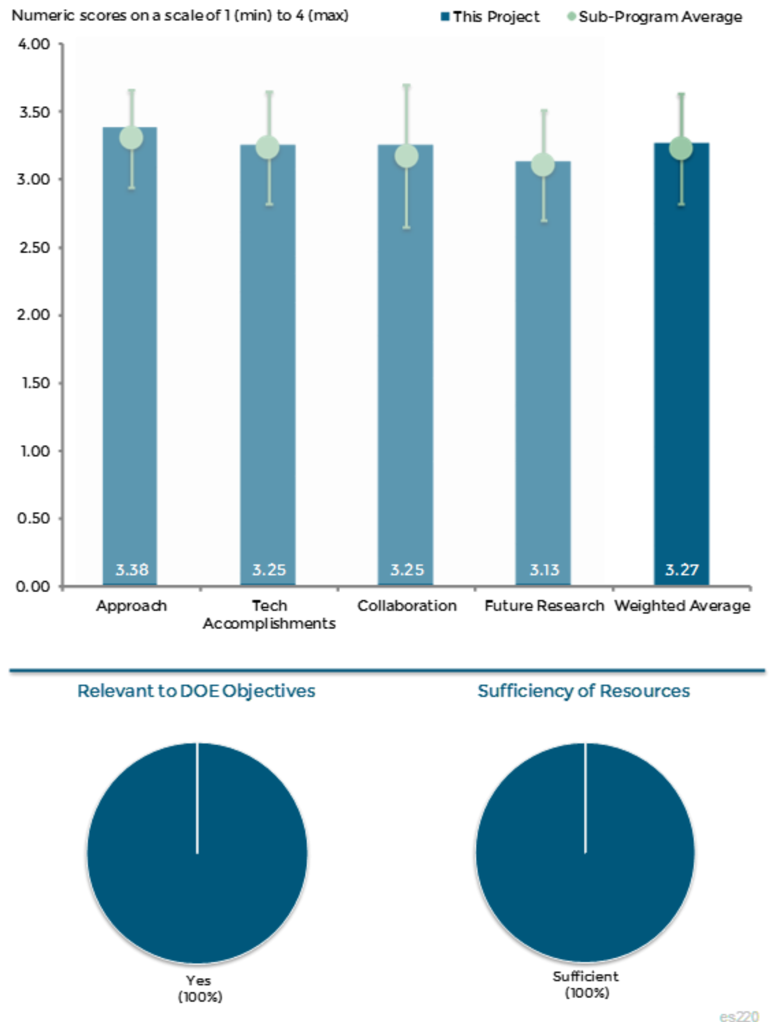


Figure 2-38 Predicting Microstructure and Performance for Optimal Cell Fabrication: Dean Wheeler (Brigham Young University) - Electrochemical Energy Storage

Presenter

Dean Wheeler, Brigham Young University.

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that the ability to detect localized changes in the conductivity of an electrode is incredibly valuable, and that this work is moving in the right direction to accomplish this goal. Battery failure begins with localized failure where identifying and eliminating these failures will lead to longer cycle lives, the use of potentially higher currents, and also an improvement to their manufacturing. The reviewer expressed a curiosity about the expected implementation of this technology as an on-line process monitoring tool.

Reviewer 2:

The reviewer noted that it is a good approach to test the microstructure and performance for optimal cell fabrication.

Reviewer 3:

The reviewer described that this approach is primarily a two-part effort. The electrode conductivity measurement studies were initiated first with a unique and excellent approach this year where the prediction of the electrode microstructure from the slurry is a much more difficult problem and was initiated in a significant way. The approach on this effort is also unique, but somewhat surprising. The reviewer expressed an expectation that the slurry drying problem would be addressed through some volume-averaged continuum-based heat and mass-transfer and surface-tension model. Alternatively, a more complex model could be used that specifically tracked the interactions of the individual particles and the solvent and binder liquid. The reviewer pointed that either of these approaches would have been very challenging, but the PI was very innovative in that the utility of an existing molecular dynamics program to describe the slurry drying process and resulting electrode morphology was identified.

The reviewer expressed that it seems that the PI has sacrificed the long term predictive capability for a short term progress. The model being developed relies on particle interaction functions that are somewhat unique to each slurry. The reviewer added that it is not clear how the PI relates these functions to things one can measure like surface tension properties. The PI appears to be generating a model that will be most useful for correlating results.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:
The reviewer commented that the PI has made excellent progress towards the project's goals on both aspects of the work, for during last year's review, the reviewer questioned the PI's ability to quickly develop a model for the slurry drying process. As described above, the PI has found an innovative way to do accomplish that task.

Reviewer 2:
The reviewer explained that up to this point, the research team has constructed a test set-up for each electrical and ionic conductivity. The work with the former team was largely completed by the last year's review, but the ionic conductivity testing has shown strong progress at this point in the work. The reviewer pointed out that the experimental set-up is still being refined, as well as the model, and although both are imperfect, given the preliminary stage of this effort, the current status is admirable. The reviewer added that it is good that the team continues to seek out additional samples, but it remains critical that this model is not limited to a specific material. Additionally, because the model seems to use a high percent of inactive material, the reviewer expressed to be not sure of the impact of this observation.

Reviewer 3:
The reviewer noted that more experiments are recommended to perform with standard commercial electrodes to demonstrate their feasibility.

Reviewer 4:
The reviewer stated that the project team designed, fabricated and tech-transferred the first generation surface conductivity probe, and this model also seemed to show good correlation between measured and predicted electrode fabrication properties. However, it is unclear if the probe will have sufficient length scale resolution of millimeter (mm) or smaller, to detect the electrode. It is also unclear if the probe will have fast response time to measure the conductivity in real time in a mass production environment. In order to demonstrate the impact of the dynamic particle-packing (DPP) model, the project team needs to use the DPP model to guide the slurry parameters, for example, viscosity and shear speed. The reviewer added that the project team also needs to correlate the optimized slurry parameters to the electrode with more uniform conductivity, and ultimately, to validate this modeled electrode with the actual performance gain in cells.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer commented that the team is actively working with industrial and laboratory partners to commercialize this technology, and are also actively working on technology transfer, which is exceptional. The reviewer stresses broader engagement, but finds no fault to be found with the current efforts and reasonably expects future efforts to attract new partners.

Reviewer 2:
The reviewer said that the PI has generated significant collaboration with industry, other program participants, and the national laboratories.

Reviewer 3:
The reviewer noted that the project team has good collaboration and interaction.

Reviewer 4:

The reviewer said that the project team has good collaboration with national laboratories and A123, but collaboration should also include making cells to validate the team's modeled electrode.

Question 4: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer mentioned that overall, the PI has a very good forward plan, and it will be interesting to see the adequacy of his model in achieving the PI's goals.

Reviewer 2:

The reviewer commented that the team is focused on increasing instrument measurement reliability and developing new probes to more fully characterize conductivity. The work on the model is ongoing in order to get better agreement with experimental data. The reviewer said that it will be interesting to track this progress at future AMRs. More specifics on the barriers of the model that are being addressed would have been desirable.

Reviewer 3:

The reviewer explained that in order to have impact, it is important for the project team to demonstrate better performance, for example, higher utilization, in a practical cell, for example, 18650 or pouch cell, with an optimized electrode based on the DPP model.

Reviewer 4:

The reviewer noted that the proposed future work should include testing of various commercial electrodes.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer said that this project will lead to more optimized electrode microstructures, that both improve the energy efficiency and the cycle life of batteries. Ultimately, this work will lead to reduced battery costs enabling further electrification of the nation's vehicles and improved gas mileage.

Reviewer 2:

The reviewer noted that this project work will reduce petroleum use.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer mentioned that the researchers are performing admirable work with the resources provided. Milestones and go or no-go decision points are being hit as would be expected.

Reviewer 2:

The reviewer stated that the PI has effectively chosen a path, in such a way, to accomplish the project's goals and overcome its barriers within the PI's budget.

A Combined Experimental and Modeling Approach for the Design of High Coulombic Efficiency Si Electrodes: Xingcheng Xiao (General Motors) - es221

Presenter

Xingcheng Xiao, General Motors.

Reviewer Sample Size

A total of three reviewers evaluated this project.

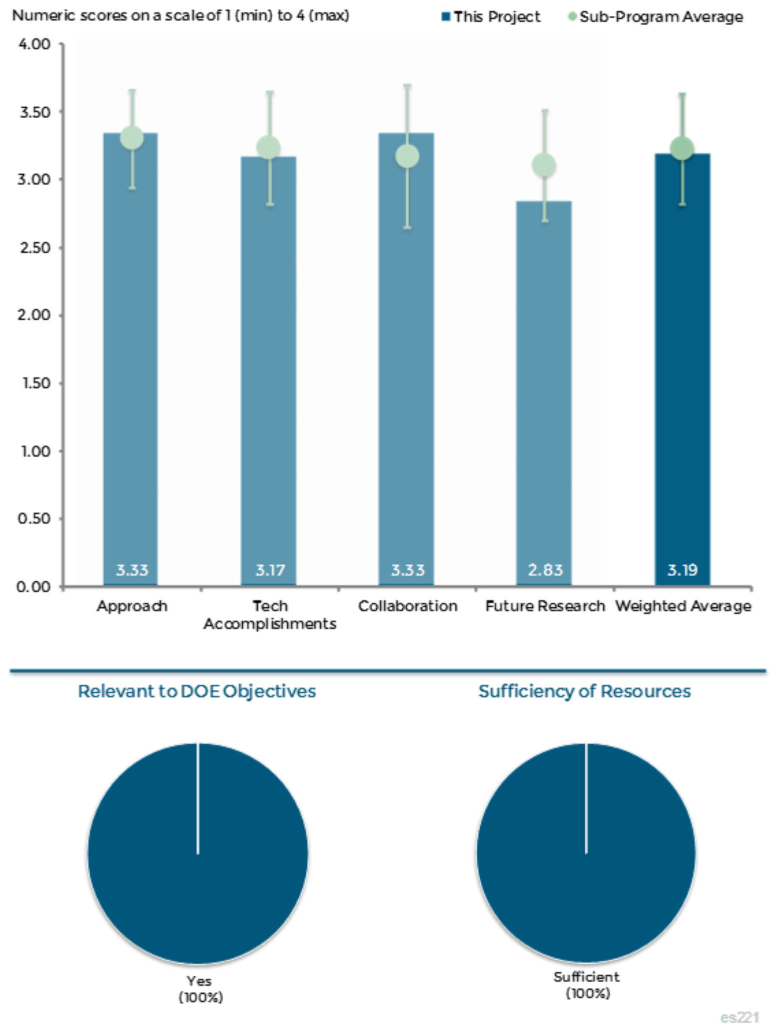


Figure 2-39 A Combined Experimental and Modeling Approach for the Design of High Coulombic Efficiency Si Electrodes: Xingcheng Xiao (General Motors) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer observed that the project team has a reasonable approach which used modeling to guide experimental design of artificial stable SEIs for Si anode.

Reviewer 2:

The reviewer said that this project addresses Si-based electrodes limitation by conducting research on the understanding and design of a stabilized nano-structured Si anode to improve Li-ion battery capacity.

Reviewer 3:

The reviewer stated that ALD coating definitely improves the stability of the Si anode and more experiments are needed rather than just performing computation.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer stated that the technical progress that has been made so far is impressive. However, it is unclear if the milestone of comparing the modeling results of SEI deformation and stability with in situ multi beam optical stress sensor (MOSS) measurement has completed or not.

Reviewer 2:

The reviewer explained that the combined DFT and continuum model has been developed to predict the mechanically stable Si-C core-shell structures, which stabilize the SEI layer and accommodate the volume expansion of Si. However, how the Si-C yolk stability is better than the Si-C core shell structure, needs to be explained.

Reviewer 3:

The reviewer reported that there seemed to be a disconnect between the modeling and experimental data, for there was no experimental cycling data on the beneficial effect of artificial SEI from ALD coating that was predicted by modeling. The project team devoted lots of effort on understanding and modeling of the SEI, but good cycling results were obtained from architecture design of Si particles such as graphene encapsulation and the York-Shell encapsulation. The reviewer expressed that the team needed to demonstrate a good cycle life with 3.5 mAh/cm^2 loading based on the approximately 1,000 mAh/g reversible capacity, and not based on the 2,865 mAh/g of initial capacity.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that the PIs have good collaborations with other institutions.

Reviewer 2:

The reviewer commented that the project team has good collaboration with other national laboratories and University of Waterloo.

Reviewer 3:

The reviewer noted that the project team has good collaboration.

Question 4: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer reported that the Li-ion battery for vehicle applications typically experience variety of charge-discharge rates, and suggested to add the understanding and characterization of designed coating to see if it is stable at higher charge and discharge rates and different temperatures.

Reviewer 2:

The reviewer noted that more experiments are recommended rather than computation work.

Reviewer 3:

The reviewer explained that the project team's data showed that the yolk-shell Si/C had better cycle life than the core-shell Si/C, but it was not clear why the team chose to focus on the core-shell Si/C for future work. In addition, the team should apply ALD coating on the yolk-shell Si/C to see if there is additional improvement. The reviewer added that the team claimed that mechanically stable coating on Si can be achieved based on the identified the proper coating thickness based on the selected coating material as shown on Slide 15, and the team needs to propose an effort to validate this claim in cells.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer said that the project supports the overall DOE objectives as it makes efforts to improve Si based anode's performance and life for Li-ion applications.

Reviewer 2:

The reviewer noted that the project reduces the use of petroleum.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer observed that it appears that there are sufficient resources for this project to achieve the proposed goals as planned.

Electrode Architecture-Assembly of Battery Materials and Electrodes: Karim Zaghib (Hydro Quebec) - es222

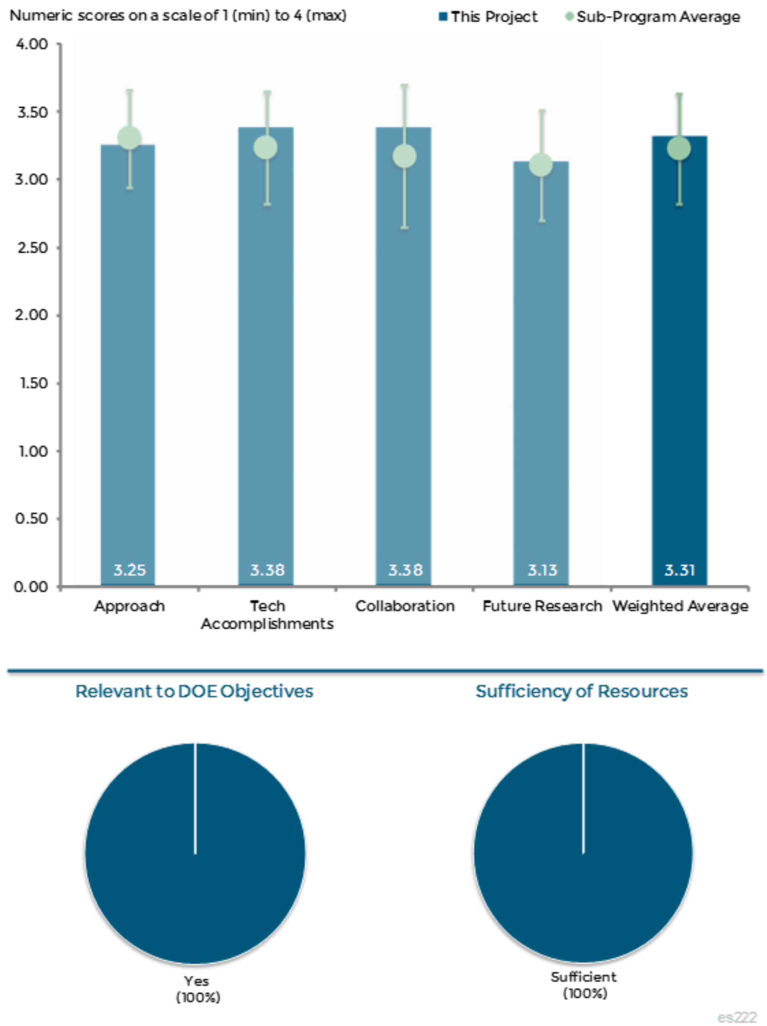


Figure 2-40 Electrode Architecture-Assembly of Battery Materials and Electrodes: Karim Zaghib (Hydro Quebec) - Electrochemical Energy Storage

Presenter

Karim Zaghib, Hydro Quebec.

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that the approach of this project is address the Si electrode’s poor life issue through the electrode architecture design, and that it is a good approach.

Reviewer 2:

The reviewer stated that the approach essentially takes a somewhat unique method of producing uniform micro-Si powder and characterizing this material as an electrode structure. This is an interesting method, and perhaps has a role in the production of Si for anode materials. The reviewer added that the basic improvement in understanding of the issues associated with Si anode development is not as strong, as referred to most of the Si based materials development activities on the agenda, but is not a negative on a relative basis to other programs.

Reviewer 3:

The reviewer commented that the project team has done excellent work on methods of producing electrode materials, but not enough strategy and focus on electrode design. The composition of the electrode, for example Si content, should be clearly stated to allow for data interpretation.

Reviewer 4:

The reviewer explained that the high-risk, multi-step process for development of nano-silicon anode material leads to very high-energy batteries, but that significant cost reduction is needed for nano-silicon anode technology to be practical.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:
The reviewer remarked that at the very least, it was impressive to see some encouraging data on electrode structures that had very high percentages of Si, which is perhaps a good material to feed into other novel electrode architectures.

Reviewer 2:
The reviewer stated that the technical achievement in this project is good, as Si nano-powder was produced and evaluated in cell. In-situ TEM analysis for Si nano-powder was conducted and samples were delivered to collaborators for their projects.

Reviewer 3:
The reviewer explained that the technical accomplishments transitioned rapidly to full-size high-performance cells, which is impressive. More full-size cells need to be subjected for extensive testing for performance and life in accordance with DOE, United States Advanced Battery Consortium (USABC) Systems, and Society of Automotive Engineers (SAE) standard test procedures, however, USABC Systems' cost model needs to be completed for this technology.

Reviewer 4:
The reviewer commented that the project team needs a clear strategy for the electrode design, which is one the main objectives of this project, and that it is important to get a better understanding of the gassing issue at every step of the process, including during electrochemical testing.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer mentioned that the project team had good collaboration with partners in several areas. The overall Hydro Quebec' (HQ) team performance and capabilities are very strong from earlier programs in advanced batteries.

Reviewer 2:
The reviewer noted that the project has a strong and highly respected team.

Reviewer 3:
The reviewer stated that project team's collaboration seemed to revolve around the delivery of materials to other organizations, where it would be interesting to have gotten some results from these collaborators.

Question 4: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer described that it will be interesting if the effect of working tempering on the relationship of life and cycle number will be included in the future study.

Reviewer 2:
The reviewer commented that the continued R&D needed to have lower costs for materials processes, and that demonstration of full capability of this technology has to be done with independent testing at DOE laboratories.

Reviewer 3:
The reviewer explained that the activities should be prioritized to support the project objectives. HQ’s desire to become a provider of baseline electrode materials should be outside of the program. The reviewer added that the comparison of the results generated by the partners will be very important.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer noted that the project has a strong and highly respected team.

Reviewer 2:
The reviewer explained that this technology can significantly improve EV and PHEV performance, life, and cost, and has potential to significantly improve vehicle range and market penetration.

Reviewer 3:
The reviewer stated that this project supports the DOE objectives by studying Si nano-powder and provides samples to support other projects.

Reviewer 4:
The reviewer that success of this project will enable next generation EV batteries.

Reviewer 5:
The reviewer noted that Si is a major material on the roadmap to high-capacity cells.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer stated that project resources should be devoted to a more complete detailing of cell tests results for performance and life, and that additional funding may be required to support this work.

Reviewer 2:
The reviewer commented that sufficient and more focus will help in achieving the project objectives.

Hierarchical Assembly of Inorganic/Organic Hybrid Si Negative Electrodes: Gao Liu (Lawrence Berkeley National Laboratory) - es223

Presenter

Gao Liu, Lawrence Berkeley National Laboratory.

Reviewer Sample Size

A total of four reviewers evaluated this project.

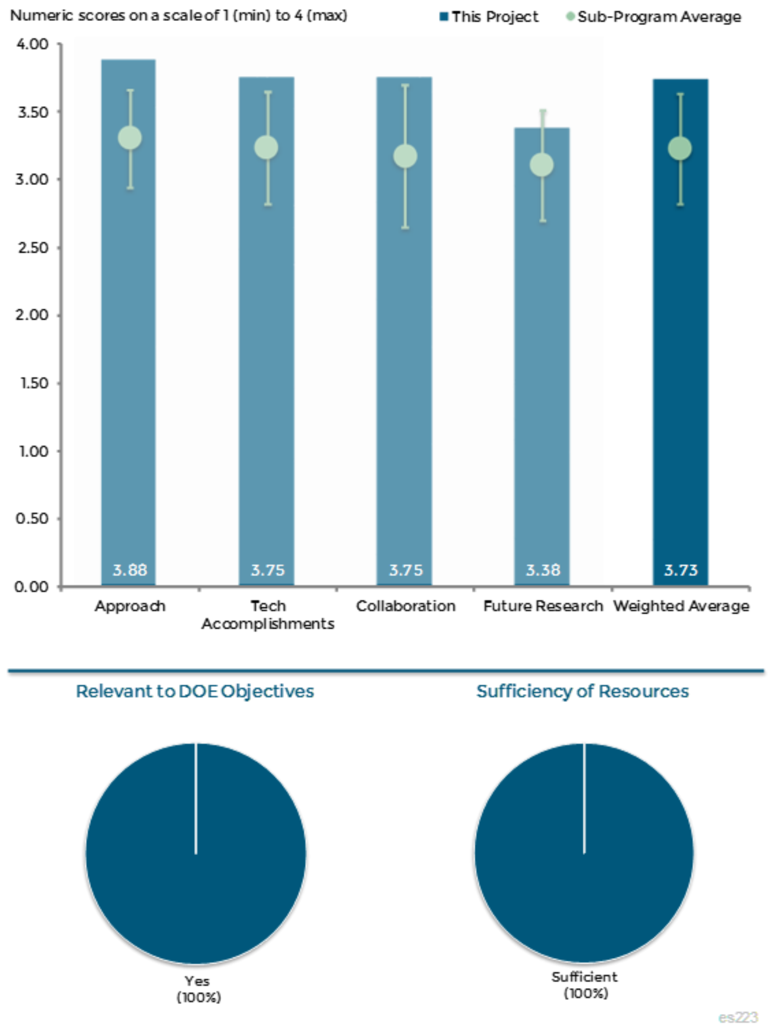


Figure 2-41 Hierarchical Assembly of Inorganic/Organic Hybrid Si Negative Electrodes: Gao Liu (Lawrence Berkeley National Laboratory) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer noted that the use of conducting polymer for Si anode is an excellent approach.

Reviewer 2:

The reviewer commented that the project team has a novel approach of using conductive polymer binder to mitigate the Si expansion issue and to improve energy density.

Reviewer 3:

The reviewer said that the PI developed a unique approach to address the short life for Si based anode.

Reviewer 4:

The reviewer stated that the technical barriers are being adequately addressed, for these functional conductive polymers are of a new type and because of that new questions and potential new avenues of research can develop. The authors, however, are well focused on the program milestones.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer commented that the approach is very well focused and the experiments are systematically performed.

Reviewer 2:

The reviewer commented that the progress achieved so far is excellent and the developed binder is promising, but inquired if the binder can be applied to cathode to reduce mechanical stress caused life reduction related to cathode.

Reviewer 3:

The reviewer explained that the project team designed, synthesized the Polypyrrole (PPy) and demonstrated a good cycle life using the PPy conductive polymer binder and also using the hierarchical electrode design. However, the data will be more impactful if the loading was also presented along with the cycling data. The reviewer commented that the team should also report the rate used in their cycling tests with a good illustration of the pre-lithiation technique using the FMC stabilized lithium metal powder (SLMP).

Reviewer 4:

The reviewer observed that the project team has very interesting data obtained with the Polypyrrole PPy polymer, and that it is very surprising that the addition of a non-conductive functionality, in regards to DOE, does not hurt conductivity. The explanation based on a smother film formation seems very appropriate, and the hierarchical electrode design seems to be a new concept. The reviewer added that using stabilized Li metal powder seems to be an interesting idea too.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer said that the project team has good collaboration with national laboratories and companies, and in addition, the role of each collaborator was clearly described.

Reviewer 2:

The reviewer commented that the authors have shown a strong collaboration with many institutions and clearly detailed their contributions.

Reviewer 3:

The reviewer stated that project team has good interaction with other team members and industries.

Reviewer 4:

The noted reviewer that there was a good collaboration for this project.

Question 4: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer noted that the project team’s future plans are good, but some of the cost involved with these polymers and the temperature effects should be addressed.

Reviewer 2:

The reviewer stated that as mentioned by the authors, the impact of additional conductive moieties should be pursued for it could be of interest to also investigate non-conductive moieties. At some point, the scalability of the process should considered. The reviewer added that some information about the NMC powder that the authors are using is also important.

Reviewer 3:

The reviewer expressed that it is important to understand and further quantify the conductive polymer, but it is more important for the team to demonstrate as was proposed, a good cycle life using the proposed conductive polymer binder but at a practical loading level of greater than 3 mAh/cm^2. In addition, the team should characterize the performance of the binder versus temperatures and rate in order to have more impact.

Reviewer 4:

The reviewer expressed that it is unclear how the binder performs in a wide temperature range and it is suggested to test the cell with the developed binder in a wide temperature range.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer remarked that yes, the work is very much aligned with the objective of petroleum displacement, for a Si containing anode is very important for high-capacity batteries.

Reviewer 2:

The reviewer noted that this technology will help reducing the use of petroleum.

Reviewer 3:

The reviewer said that the successful development of a conductive binder will help to increase of battery life with Si electrode.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that the authors have been careful in staying on course, but may need additional resources if the team can expand their study into new areas that may develop during their research such as scale-up operations.

Simulations and X-ray Spectroscopy of Li-S Chemistry: Nitash Balsara (Lawrence Berkeley National Laboratory) - es224

Presenter

Nitash Balsara, Lawrence Berkeley National Laboratory.

Reviewer Sample Size

A total of four reviewers evaluated this project.

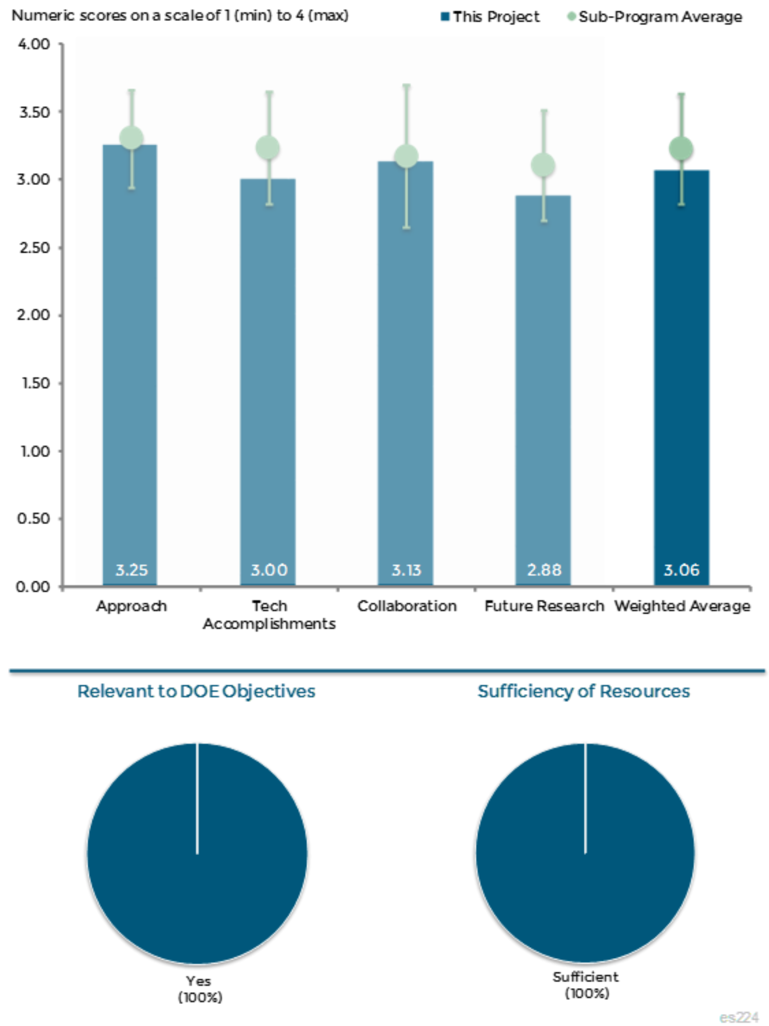


Figure 2-42 Simulations and X-ray Spectroscopy of Li-S Chemistry: Nitash Balsara (Lawrence Berkeley National Laboratory) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer pointed out that the first-principle simulation method has been used to aid the experimental characterization of reaction products, which helps provide new insight into the redox reaction pathways on the cathode side of Li-sulfur (S) batteries. The X-ray absorption spectroscopy (XAS) is the major characterization tool used in the project due to its unique characteristics. The reviewer suggested that the researchers comprehensively utilize other ex-situ or conventional microscopic and spectroscopic tools such as Raman, XPS, SIMS, SEM, HRTEM, STEM and EELS to provide the supporting evidence for identifying the intermediate and the final reaction products after operation of the cathode.

Reviewer 2:

The reviewer explained that the fundamentals of Li-S chemistry are well known for a long time, but the current project is trying to address the stability of the sulfides at various potentials that are important for Li-S battery. It is good to show that the stability of the sulfide species, but the project team should correlate with the sulfur dissolution.

Reviewer 3:

The reviewer stated that only the design of lithium sulfur cells with polyethylene oxide (PEO) cannot help in revealing the nature of the products produced during the electrochemical processes. Extending this interesting study to other type of electrolytes is recommended.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer explained that the results have demonstrated that the XAS and simulation can be successfully used for characterizing the intermediate and the final reaction products, and that the research could eventually unveil the redox reaction pathways on the cathode of Li-S battery. Identification of reaction products at the early discharge stage have shown some very interesting results. The reviewer expects that the redox reaction pathways on the cathode will be studied after or during the charge-discharge cycle, and it is interesting to check the products after different cycles of operation.

Reviewer 2:

The reviewer explained that the fact that the Li-S battery operated at 90°C can be misleading with regard to the produced products, although one can understand that with PEO there was a need for a high-temperature charging and discharging. In this case, it is recommended to look at a conventional electrolyte that can be used effectively at room temperature and perform the same XAS experiment for the purpose of comparison. The reviewer also stated that the team should be careful toward generalizing that the radical is generated during the early stage of the discharging process. This statement can only be true if the study were to be extended to other electrolytes.

Reviewer 3:

The reviewer commented that it would be helpful if the team can determine the precision and accuracy, as well as the detection limits, of polysulfides that can be measured by XAS combined with simulation. For example, the standard deviations should have been provided in the Table on Slide 13 of the presentation. The reviewer added that it would valuable if the team can elucidate whether thermodynamics or kinetics is responsible for the absence of the reactions shown on Slide 15.

Reviewer 4:

The reviewer stated that it will be good if the PI can address the sulfur dissolution problem related to the stability so that the major issue of sulfur cathode dissolution can be explained, and that more experiments will be good in comparison to computation.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted that the project has good teamwork.

Reviewer 2:

The reviewer said that the PI has addressed the previous review comments, and collaborated with other leading units to extend the research scope.

Reviewer 3:

The reviewer commented that project team needs more collaboration with the sulfur cathode group so that the PI can attack the specific issue in sulfur dissolution.

Reviewer 4:

The reviewer wondered if it is possible that too many collaborations would defocus the project, especially because many collaborators are outside of VTO.

Question 4: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer explained that it is very significant to conduct the XAS measurement of a cathode under the in-situ or operando condition. The effects of the charge-discharge process, the operating temperature, and the cycling on the reaction pathway can be clarified more clearly under the in-situ condition.

Reviewer 2:

The reviewer expressed that the project team use fundamental knowledge to build a Li-S cell with long cycle life and high-energy density, for enough experimental evidence is already present. The PI should discuss and collaborate with other lead researchers in the S area and try to help the issues such as sulfur dissolution.

Reviewer 3:

The reviewer said that more experimental work is needed, and that it is recommended to include low-temperature electrolytes to this work.

Reviewer 4:

The reviewer stated that the team should be more aggressive in using XAS to solve the polysulfide dissolution problem instead of just characterizing the problem.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that the ongoing research is well aligned with the mission and the objective of DOE program.

Reviewer 2:

The reviewer said that this project deals with the understanding of the Li-S battery, which the most important step before these kind of batteries can be suited for practical use.

Reviewer 3:

The reviewer noted that this work reduces the consumption of petroleum use.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that reasonable resources are allocated to the project at this stage.

Design and Synthesis of Advanced High-Energy Cathode Materials: Guoying Chen (Lawrence Berkeley National Laboratory) - es225

Presenter

Guoying Chen, Lawrence Berkeley National Laboratory.

Reviewer Sample Size

A total of three reviewers evaluated this project.

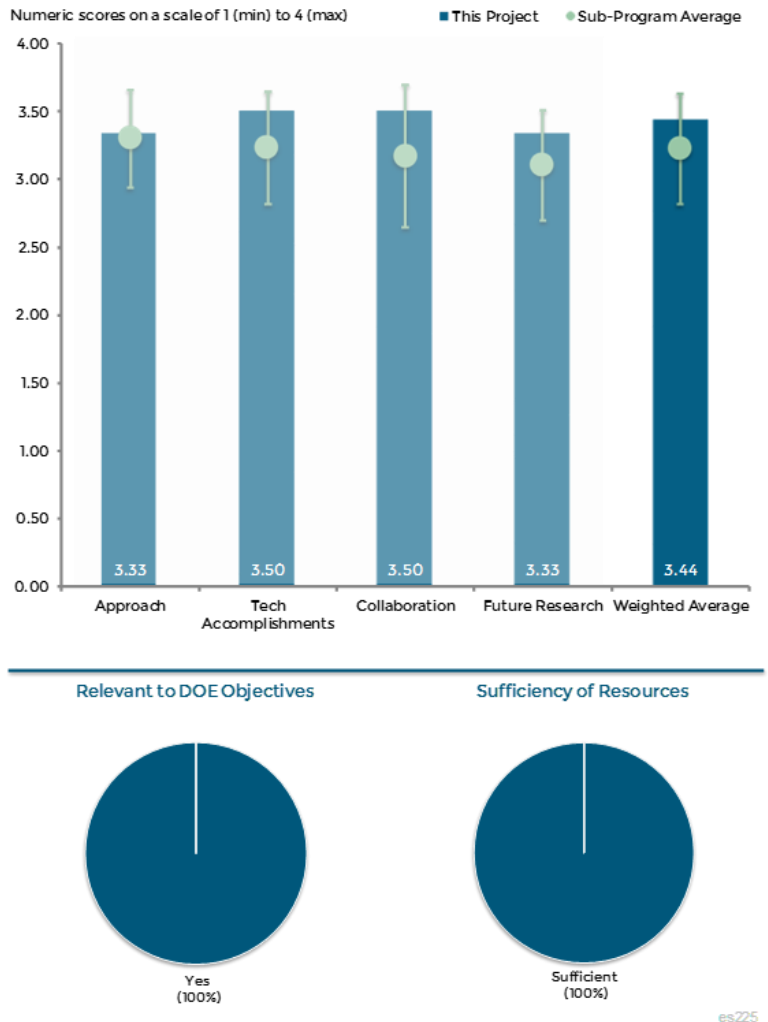


Figure 2-43 Design and Synthesis of Advanced High-Energy Cathode Materials: Guoying Chen (Lawrence Berkeley National Laboratory) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that the key focus areas of the work, such as understanding of phase transition, cathode and electrolyte interface, and transport limitations, received superb attention.

Reviewer 2:

The reviewer noted that that the project team has a good approach to synthesize single crystals and to understand the bulk verses surface effects on performance of the LMR-NMC high-voltage cathode.

Reviewer 3:

The reviewer said that the project team’s approach is solid and strong, but to meet DOE vehicle goals, electrode materials with high-energy density and high stability are required. Advances in materials development, therefore, require a better understanding of the relationships between electrode material properties and functions. The reviewer pointed out that the PI is removing the complexity of many similar investigations in the past by synthesizing well defined crystal systems. The advanced diagnostics, both ex-situ and in-situ, and experiments to characterize crystal properties and interfacial chemistry compliment the effort and will aid in the development of rationally designed electrodes.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer described that the team has carried out high-quality studies to unravel the issues that plague the LMR-NMC cathodes, and that work on single crystals, especially the characterization studies using STEM and x-ray techniques, have been superbly carried out, and the results are really insightful. Transition metal (TM) dissolution and migration surface property characterizations have also been carried out superbly, and therefore, the resources are well spent.

Reviewer 2:

The reviewer stated that excellent progress was achieved this year, and that a host of LMR-NMC crystal samples were synthesized. The team revealed the contribution of key surface properties to the material challenges confronting the LMR-NMC cathode. In addition, diagnostic techniques were developed that can be used for single-particle based investigations. As a result of these efforts, there were numerous papers and presentations.

Reviewer 3:

The reviewer explained that a lot of data was presented on correlating surface morphology with performance, but it was not clear if the data was based on single cell or multiple cells per given type of surface morphology. The project team needed to provide statistics on the performance data in order to rank S-poly, L-poly and plate results and to identify one morphology with overall good performance. The reviewer said that some explanations are needed on how the surface spinel group affected the voltage fade which was thought to be induced by bulk structural change. The impact of electrode fabrication, for example, grinding, mixing, etc., on the morphology of the crystals, should be quantified since the morphology might not be maintained after the electrode fabrication and after the first activation charge when O_2 gas was evolved at high cut-off voltage.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer said that there is outstanding collaboration in this effort. The team consists of well-known scientists from Cambridge, University of California at Berkeley, University of California at San Diego, Oak Ridge National Laboratory (ORNL) and Pacific Northwest National Laboratory (PNNL).

Reviewer 2:

The reviewer stated that the project team has extensive collaboration with pertinent laboratories.

Reviewer 3:

The reviewer noted that the project team has good collaboration with national laboratories and companies.

Question 4: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that the list of future work is very extensive and hopes the authors continue to deliver the same high quality results as they have done during this review period.

Reviewer 2:

The reviewer remarked that these efforts will continue to further investigate the effect of synthesis and particle morphology on battery performance. The team will use the information to explore particle engineering to improve cathode performance and stability.

Reviewer 3:

The reviewer explained that proposed future work appeared to be a continuation of the fundamental characterization reported in 2015, but the proposed techniques to mitigate the cathode stability issue were vague. The project team needed to propose more specific surface modification techniques to improve the cathode stability by leveraging insights gained on the surface defect spinel.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer remarked that definitely yes, the high-capacity cathode is the key to the development of high-energy batteries.

Reviewer 2:

The reviewer noted that the goals of this project are consistent with DOE Vehicle Technology goals.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that that the funding level seems appropriate.

Microscopy Investigation on the Fading Mechanism of Electrode Materials: Chongmin Wang (Pacific Northwest National Laboratory) - es226

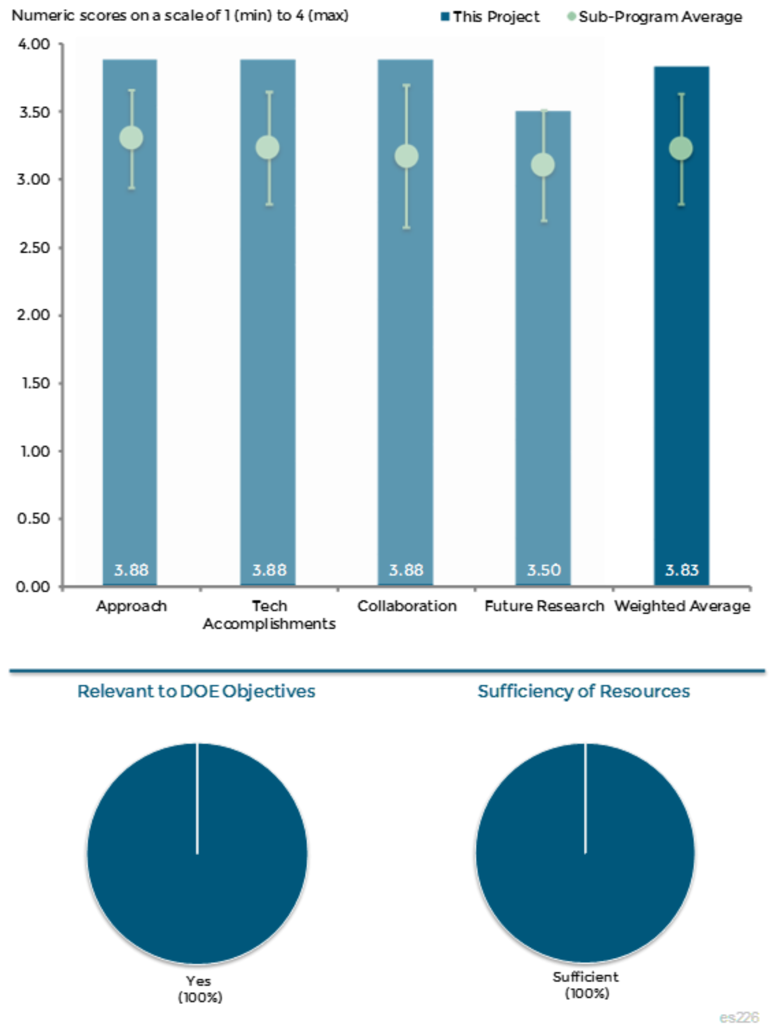


Figure 2-44 Microscopy Investigation on the Fading Mechanism of Electrode Materials: Chongmin Wang (Pacific Northwest National Laboratory) - Electrochemical Energy Storage

Presenter

Chongmin Wang, Pacific Northwest National Laboratory.

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer said that this project is developing a suite of advanced characterization and diagnostic tools to decipher how and why materials work. The in-situ and in-Operando tools developed by the PIs are especially important to the field, for the materials and issues they selected are all of high-importance to the DOE BMR programs.

Reviewer 2:

The reviewer commented that the approach has good combination of multiple diagnostics approaches to understand battery operation and degradation modes, and created three in-situ TEM tools.

Reviewer 3:

The reviewer stated that the PI used Operando HRTEM to probe the fading mechanism of Si anodes and high-capacity cathodes.

Reviewer 4:

The reviewer reported that the ex-situ, in-situ, and Operando HRTEM has been used to investigate the fading mechanism of electrode materials, and that so far, few studies have been performed on the electrode materials under the operando condition. The Operando HRTEM provides a unique approach for unveiling the time-resolved structure evolution on the nano-scale and atomic scale. The reviewer explained that this work is a big step forward in characterization of battery electrode materials, and that it is worth noting that the electrode materials are subject to bombardment of a high-energy electron beam during HRTEM observation. The reviewer was curious whether any damage of electrode materials was observed by the high-energy electron beam, and how such possible damage of electrode materials can be minimized or avoided completely.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer commented that the results obtained from the in-situ and Operando HRETM experiments are very exciting, as for example, the HRTEM observation has found the gradual phase transformation C2/m to I41 to spinel in the $Li_{1.2}Ni_{0.2}Mn_{0.6}O_2$ electrode. The decrease in the Ni concentration inside the particle following cycling and the spatial partition of Ni and Mn at the edge indicate dissolution of Ni into electrolyte. The reviewer pointed out that the project team has also observed the oxygen loss and the Li depletion near the surface region in the Li_2MnO_3 electrode. These results have provided the direct evidence of electrode degradation, which will have important implication in designing electrode materials.

Reviewer 2:

The reviewer observed that the project team did a very nice demonstration that the O-layer on Si creates lithium oxide (Li_2O) when Si is lithiated, and though this has been understood for some time, it is nice to be shown. The project team has also investigated the function of an Alucone coated Si and shown how it impacts cycle life, but however, if Alucone consumes the silica oxide (SiO_x) particles, then one is probably losing active Li. The reviewer said that it would be interesting to investigate how to eliminate the silica oxide (SiO) from the anode material, to show surface segregation of Ni on LiNiMnO cathodes which is something that has been found in the past by Manthiram at Texas, and to also find dissolution of Ni into the electrolyte, similar to what was discovered on nickel cobalt aluminum (NCA) cathodes in the 2000 decade.

Reviewer 3:

The reviewer remarked that the PI's work on Si anodes and other cathodes is excellent, which included five papers published in high impact journals. The reviewer suggested that the team use closed cell to study surface sealed research, for the open cell is only suitable for internal structure study of the electrode, while the closed cell is suitable for the electrode and electrolyte interface study such as SEI.

Reviewer 4:

The reviewer stated that the PIs have completed the proposed milestone of devising liquid cells, which is of primary importance to the field. The SEI study on Si and Li protection and dendrite growth study under TEM would provide the most important info to the researchers in the area of BLI chemistries.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer commented that the PIs have demonstrated excellent collaboration with other laboratories, especially the material developers.

Reviewer 2:

The reviewer stated that the project team has very good collaboration with universities, national laboratories, and companies, but would like to see increased focus on problem solution, following the excellent problem elucidation demonstrated here.

Reviewer 3:

The reviewer said that the PI has collaborated with multiple national laboratories, universities, and instrument vendors, and that the collaboration is productive.

Reviewer 4:

The reviewer noted that the PI closely worked with other PIs in the program.

Question 4: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer noted that the planned direction fits well with DOE's BMR focus and vision.

Reviewer 2:
The reviewer mentioned that to study SEI and coating on Si and LMR, NCM and NCA should use closed cell because it is related to the reaction to electrolyte.

Reviewer 3:
The reviewer explained that the proposed future work is timely and critical to the development of electrode materials, but the Operando cell under HRTEM needs a microfabrication facility. The reviewer asked if the PI has confirmed the availability of a microfabrication facility and necessary expertise. When a liquid cell is used under the HRTEM, the spatial resolution is reduced compared to the dry solid-state condition. The reviewer is curious about the best spatial resolution that can be achieved with the use of liquid cell.

Reviewer 4:
The reviewer was unsure that more work on Li dendrites is needed because there are already 30 years of work on that system, including diagnostics work. The reviewer liked the focus on understanding and trying to develop mitigation strategies for specific issues known to cause rapid capacity or power fade in high-energy electrodes.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer noted that the ongoing research is well aligned with the mission and the objective of DOE program.

Reviewer 2:
The reviewer mentioned that the in-situ TEM study is important for understanding the mechanism of capacity decay due to the structure change of the electrodes.

Reviewer 3:
The reviewer remarked that yes, the work obviously supports DOE objectives.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer stated that the project costs are a very good value for a national laboratory, which is usually more expensive than $200,000-$300,000 per year.

Reviewer 2:
The reviewer said that the project's resources are sufficient.

Reviewer 3:
The reviewer noted that PNNL has the facilities for proposed research.

Reviewer 4:
The reviewer stated that no comments were necessary.

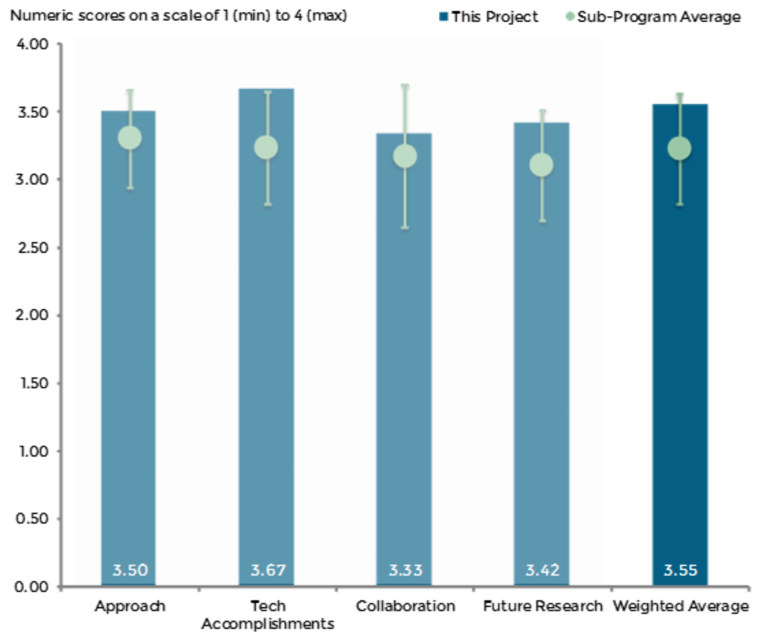
BatPaC Model Development: Shabbir Ahmed (Argonne National Laboratory) - es228

Presenter

Shabbir Ahmed, Argonne National Laboratory.

Reviewer Sample Size

A total of six reviewers evaluated this project.



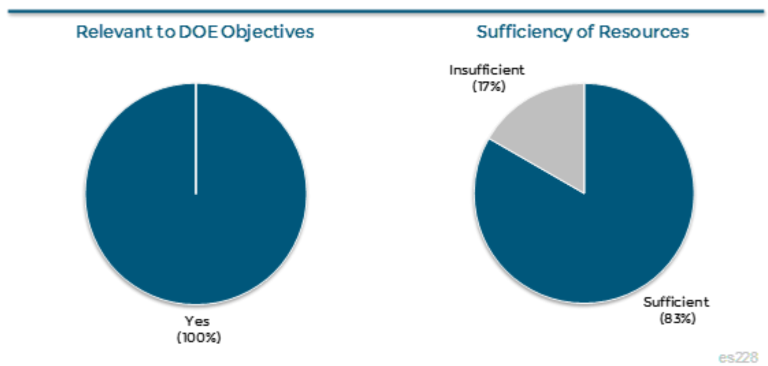


Figure 2-45 BatPaC Model Development: Shabbir Ahmed (Argonne National Laboratory) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that this is a well-focused project to develop design and simulation capabilities for assessing performance and cost of Li-ion batteries.

Reviewer 2:

The reviewer noted that there were vast model improvements in manufacturing assumptions and process improvements, which appear very logical and accurate. The depth of knowledge to support this model is apparent when reading of the process for recovery of volatile organic compounds (VOCs) or N-Methylpyrrolidone (NMP).

Reviewer 3:

The reviewer noted that the PI has the knowledge of the critical input needed for high reliability estimates for building a factory and processing operations to fabricate cell components.

Reviewer 4:

The reviewer reported that the approach taken to develop the Li-Ion BatPaC model contributes greatly to the improvement in performance and cost prediction of known battery chemistries, and it was clear that a lot of work went into the development effort for modeling both cell and to some degree battery pack costs. The approach to highlight manufacturing cost reduction methods and selecting a key process to address in presentation was great.

The reviewer expressed as one point for future consideration, there should be a clear indication of whether the data being presented is for a plant that builds battery cells, or a plant that builds battery packs and modules from cells. Slide 8 discusses a flex plant producing batteries, but the second bullet indicates that this plant actually produces cells. The next slide then discusses this same flex plant producing battery packs, and the following slide then indicates this is a cell plant as it talks about N-Methyl-2-pyrrolidone (NMP) recovery, which was a bit confusing. There were other instances of the information being great, but confusing in presentation. The reviewer thought Slide 13, for example, is great information for cell production. The reviewer unsure, however, of the value for a battery pack production facility.

The reviewer's assumption is that the information is for a cell manufacturer that produces the equivalent number of cells for this battery packs discussed, however this is not clear. The reviewer thought that the cell and battery terms are used interchangeably at times and that is where some confusion arises.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer reported that the presented data showed excellent progress towards the stated goals for this phase of program, which was good information for battery suppliers and users for identifying process change opportunities that could decrease overall cell production cost. The reviewer assumed that this information is for the battery cell manufacturers and those that track their cost, for cost savings to the cell manufacturer should ultimately result in cost savings to battery manufactures and users. This BatPaC model is of great value to automotive manufacturers of vehicles with electrified powertrains. The reviewer especially liked the analysis data that showed that a uniform electrode size (length and width) could be used for the cell for most batteries by just varying other cell characteristics, and how that would be a big cost savings.

Reviewer 2:

The reviewer stated that the flex-plant parameters will improve the factory cost estimates. The decision on using uniform electrode size of length and width, helps with the thickness of the electrodes.

Reviewer 3:

The reviewer noted that as being a BatPaC user, the progress is a good combination of user friendly and industrially relevant.

Reviewer 4:

The reviewer commented that the data obtained for the use of flex-line are very interesting if the footprints are closely matching, but is not sure how the changeover time was taken into consideration while calculating the cost or line efficiency. Line change could involve weeks of downtime. The reviewer added that the energy calculations for solvent recovery, and especially for dry-room operation, are very instructive and useful, and would like to know how many vendor responses were used to come up with these values.

Reviewer 5:

The reviewer stated that at the risk of redundancy to the prior question, this BatPaC model addresses the core processes and material assumptions that define the Li-ion battery (LIB), and therefore, barriers can be identified and addressed. As LIB technology is core to DOE energy storage goals, this type of project is clearly at the core of DOE's goals.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer said that project team's collaboration has been excellent.

Reviewer 2:

The reviewer pointed out that the project has utilized key and industry leading collaborators such as LG Chem, General Motors Company, 3M Company, and others to define assumptions, processes, and validate assumptions, and could not think of a better collaboration.

Reviewer 3:
The reviewer described that project team’s collaboration with significant high-volume cell manufacturers, via confidential information exchange agreements to include more real-world information, could be an improvement opportunity towards greater level of output reality. This work may be best accomplished by organizations outside of ANL, which can give best assurance to collaborators of information protection, while still allowing ANL modelers to the access of their generalized model data.

Reviewer 4:
The reviewer stated that collaboration partners included cell materials developers and manufacturers as well as battery manufacturers, and also one of the world's largest automotive battery users. This type of collaboration is needed to keep this effort up to date and moving forward.

Reviewer 5:
The reviewer commented that the partners are the battery developers and producers who will be able to validate the model.

Reviewer 6:
The reviewer noted that high-volume battery producers were conspicuously absent.

Question 4: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer noted that the continuing research will make the model more useful.

Reviewer 2:
The reviewer explained that as was stated prior, and to have worked with the model years ago, one can witness increased fidelity to the processes and associated barriers. Through this timed perspective, one can see the great thought that has entered the logic flow for model maturity.

Reviewer 3:
The reviewer commented that because all suppliers are moving towards single cathode systems, it will make sense to carry out the studies with blended cathode systems, and recommended expanding the future collaboration to include low-cost suppliers in China who increasingly play a big role in component sourcing. The reviewer asked if energy calculations will also be done for formation systems.

Reviewer 4:
The reviewer stated that the cathode work is heavily weighted in this model as compared to the other cell components, and that the other cell components need more attention, the anode and separator in particular. There was no clear indication of the effort that would be expended toward the analysis of these other components in future work, and no clear mention on directional information for cell format and tab designs being added to the model. The reviewer commented that this would also be very helpful for both cell manufacturers, battery pack builders, and automotive customers.

Reviewer 5:
The reviewer would like to hear more on other cell formats and capacity.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer remarked that yes, the work does support DOE objectives. Having a reliable cost model especially those that deal with the use-line efficiency and energy consumptions, are very useful for developing cost-effective cells and batteries.

Reviewer 2:

The reviewer explained that the BatPaC model helps identify ways that a cell manufacturer can realize a meaningful cell cost reduction, for the cell cost is at least 50% of an automotive battery cost. Cost is one of the biggest hurdles for adoption of this technology as a viable alternative to the ICE, and consequently, any system that allows for a meaningful cell-cost reduction supports the DOE objective to reduce petroleum usage.

Reviewer 3:

The reviewer reported that this BatPaC model addresses the core processes and material assumptions that define the LIB, and therefore, barriers can be identified and addressed. As LIB technology is core to DOE energy storage goals including petroleum displacement, this type of project is clearly at the core of DOE goals.

Reviewer 4:

The reviewer noted that the optimized cost and performance estimate help the cell developers produce and sell batteries to the automotive OEMs.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented that this project seems to have a good return on investment (ROI) and warrants future updates and support.

Reviewer 2:

The reviewer stated that the resource support of the ANL modelers and the industry will be sufficient to achieve the milestones.

Reviewer 3:

The reviewer stated that the resources provided to the project should be sufficient to meet the stated milestones.

Reviewer 4:

The reviewer commented that project’s funding level seems to be okay.

Reviewer 5:

The reviewer noted that any signs of project funding short-falls or excesses are not apparent.

Lithium-Ion Battery Production and Recycling Materials Issues: Linda Gaines (Argonne National Laboratory) - es229

Presenter

Linda Gaines, Argonne National Laboratory.

Reviewer Sample Size

A total of six reviewers evaluated this project.

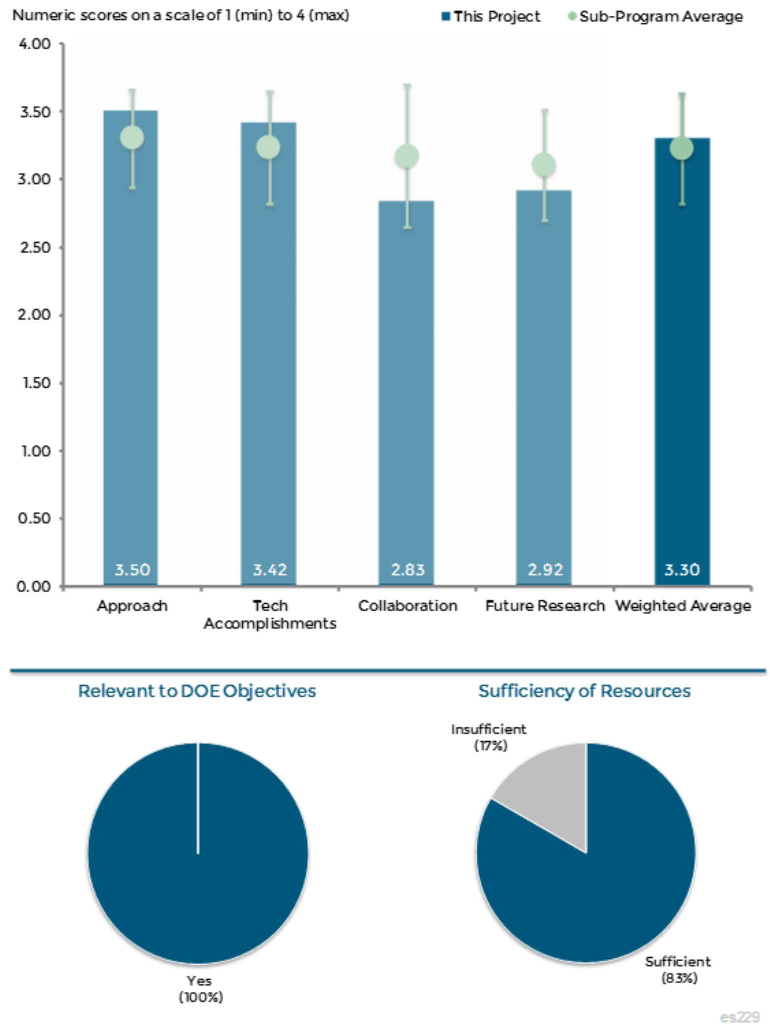


Figure 2-46 Lithium-Ion Battery Production and Recycling Materials Issues: Linda Gaines (Argonne National Laboratory) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer said that the project is well-planned, comprehensive and has very focused goals.

Reviewer 2:

The reviewer stated that the project objectives are clearly identified as well as having potential methods to address them, as production and recycling of Li-ion batteries are two very big issues that are being addressed. The approach to address these issues and their impact on the environment was very inclusive and made use of the tools and information available. The reviewer, however, would have liked to have seen more involvement from battery users.

Reviewer 3:

The reviewer noted that the battery manufacturing issues similar to energy consumption are being addressed along with the difficulties in recycling.

Reviewer 4:

The reviewer stated that this subject matter is difficult and complicated, but essential for success of the LIB technology. This work has been an arduous and lengthy process since 2008. Therefore, in the bigger picture, the reviewer wants to understand how this work is going to close the loop and be used to drive decisions in LIB development in both industry and future DOE program definitions.

Reviewer 5:

The reviewer commented that the approach is otherwise excellent except for three issues; First, the reviewer noted many references and comparisons to lithium cobalt oxide (LCO) cathode material. The reviewer asked if it is used in automotive applications at all. If not, then if a comparison is made, it should be noted that it is used in consumer electronics applications included only as a reference due to high-volume usage in non-automotive applications. The reviewer remarked that the second issue is that the intermingling of Li-ion into lead-acid battery recycling is important issue, but asked if this work is doing anything to contribute to resolution of this issue from a scientific or technical perspective. If nothing, then it seems like using project is to promote industry special interests and hype. Thirdly, the reviewer commented that a portion of activity in this particular project involving the study of cathode exposure to acids or bases seems inappropriately primitive. Argonne should be capable of something much more relevant and insightful.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer noted that the team has been generating a lot important and relevant data from material availability, recycling, and energy consumption points of view. These are very useful and much appreciated, and the PI's work is a great source of valuable information.

Reviewer 2:

The reviewer reported that project team's nearly outstanding progress is an excellent accomplishment. The reviewer had one comment on Slide 13. It was not very clear whether this was related to the mining of the material, the recovering of the materials from a recycled product, or from both. There is a good summary on battery life-cycle impact on environment, and the project shows areas of opportunities for improvement for both carbon dioxide (CO_2) and sulfur oxides (SO_x) emissions reductions. The reviewer said it would be good for a separate study to identify potential ways to reduce even further the plant CO_2 emissions, and identify ways to reduce the SO_x emissions during carbon monoxide (CO) and Ni mining operations assuming that the mining operation is the biggest contributor to this SO_x emission. The reviewer added that the project team has a really good analysis showing various recycling methods and how they impact energy usage and emissions generation.

Reviewer 3:

The reviewer noted that the detailed cradle-to-gate analyses and comparisons are useful, and that the project team has excellent accomplishments given the budget of the program.

Reviewer 4:

The reviewer commented that contacts have been established to complete the task.

Reviewer 5:

The reviewer asked what usage metric is used to define the baseline for the analysis, or what volume and ramp rate by 2050, in terms of the material scarcity. The reviewer was pleased to see that the BatPaC and Greenhouse Gas, Regulated Emissions, and Energy Use in Transportation (GREET) models are publically being utilized for other than U.S. Environmental Protection Agency (EPA) or CAFE analysis.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted that the project team has excellent collaboration given the size of the budget.

Reviewer 2:

The reviewer remarked that additionally, Toxco (Retrieve) might be added as a collaboration partner because the company is already helping the battery industry to recycle some of the chemistries.

Reviewer 3:

The reviewer explained that from the material scarcity and battery production perspective, this project may consider additional industry partnerships that have performed similar analysis with financial risk. The reviewer said that if from the recycling perspective, arguably the most important portion of this project, if the project team has considered analysis beyond the technical and economic perspective, for example, from governmental policy on a world-wide basis.

Reviewer 4:

The reviewer expressed that encouragement for a much wider collaboration with material vendors and manufacturers, especially those in Japan and China, to obtain process info and cost for having improved reliability.

Reviewer 5:

The reviewer would like to see more involvement with automotive battery users, for the involvement of the EPA or other regulatory type organizations was not clearly stated, for their direct involvement would have been great, if possible.

Reviewer 6:

The reviewer noted that the project team did not cover much collaboration in the presentation.

Question 4: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer reported that program recognizes the ongoing work that is needed and the appropriate modeling tool needed support, where future work appears to include the effort to improve process development, but the key development areas were not clearly and sufficiently identified. Looking at using recycled batteries from consumer devices as feedstock for inclusion in the development of automotive batteries is good. The reviewer would like to see support from automotive OEMs and strong Li-ion battery suppliers included, and how environmental agencies support this effort in some way, as well as SAE or similar organizations. Finally, there should be some effort added to identify non-intrusive ways to strongly encourage the return and collection of the used consumer and other Li-ion battery cells and batteries.

Reviewer 2:

The reviewer stated that future research should include alternative demand of cathode materials for consumer battery using the automotive recycled batteries.

Reviewer 3:

The reviewer commented that perhaps redundant to a prior statement, there is a desire that a closing of the loop must be accomplished to complete this work.

Reviewer 4:

The reviewer is keen on learning how these future estimations are affected when one also considers batteries for energy storage use.

Reviewer 5:

The reviewer commented that there is not much detail on future work in the presentation.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer said that this project work is a highly relevant topic because life-cycle assessment (LCA), recycling of batteries, and energy consumption of various processes are critically interrelated to the DOE objectives.

Reviewer 2:
The reviewer reported that this work strongly supports the DOE objective to displace petroleum usage, for the recycling cost of these batteries could become a defining barrier or become an environmental disaster because of cost to the end user. Customers may decide to not purchase battery powered vehicles because the recycling cost could be as much as 10% of the initial battery cost.

Reviewer 3:
The reviewer remarked that yes, the project supports the DOE objectives because it is working on the enablers of electric storage technology.

Reviewer 4:
The reviewer noted that the cost of recycling will help with the cost estimation of new batteries and justify for more effective use of the automotive EV batteries.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer explained that there are many different directions for this project to be expanded that will reduce the overall cost for the industry at both the vehicle OEM and consumer usage levels. Additionally, more funding is needed to reduce the potential negative environmental impact today, in the near future, and in the relatively near term future. The reviewer added that these are the reasons that one thinks that more funding is needed in this area.

Reviewer 2:
The reviewer commented that the project team has pretty good judgment in managing scope and mission creep.

Reviewer 3:
The reviewer noted that the ANL researchers and the industry partners will help with the resource issues.

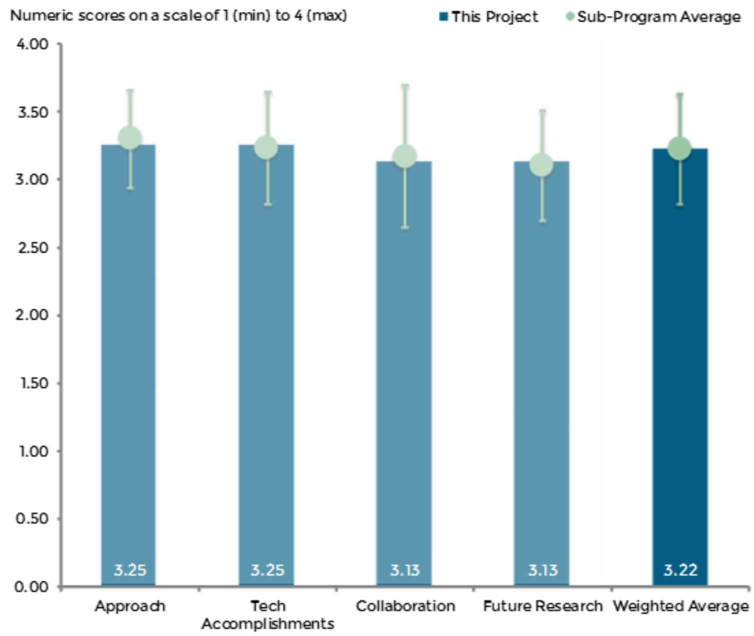
Sulfur Cathode for Lithium-Sulfur Batteries: Yi Cui (Stanford University) - es230

Presenter

Yi Cui, Stanford University.

Reviewer Sample Size

A total of four reviewers evaluated this project.



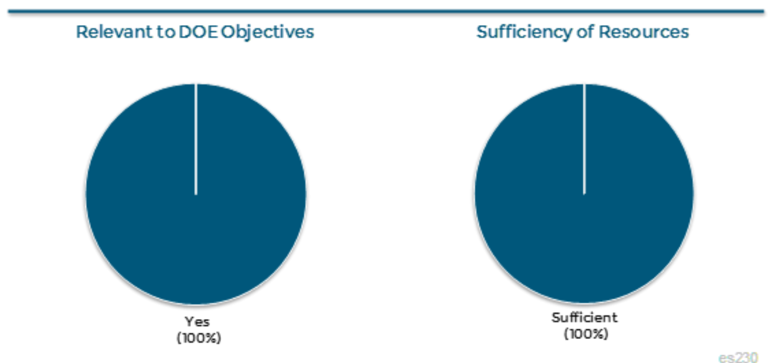


Figure 2-47 Sulfur Cathode for Lithium-Sulfur Batteries: Yi Cui (Stanford University) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer reported that the approaches are well outlined in a comprehensive fashion, where experiments combined with simulation have been used to develop the cathode and microscopic characterization and electrochemical testing have been utilized to evaluate the cathode. The reviewer also commented that it would be good if the principle and rational for material design are elaborated and justified.

Reviewer 2:

The reviewer stated that the approach of making nano-sulfur and the architecture is good, but the PI should focus on attacking one architecture instead of several structures.

Reviewer 3:

The reviewer said that the approach is relevant although one can argue that the inclusion of an electrolyte study could make this study more comprehensive.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer pointed out that outstanding results have been obtained in a systematic way, and that the extension of the study to lithium sulfide was a good move. Sulfur cathode development is important, however, it is recommended to include some electrolyte related work.

Reviewer 2:

The reviewer explained that several composites including the hydrogen-reduced titanium dioxide (TiO_2-x) inverse opal sulfur, the Magnéli-phase TiO2n−1 nanomaterial, the hollow S-amphiphilic polymer nanoparticles, and the conductive polymer-coated hollow sulfur have been developed, and that such scaffolds or coatings for the sulfur cathode have improved the cyclic stability significantly. The reviewer said that it would be great if the PI can address the common and the difference in the rational for designing different composites. The focus of this project is on the development of cathode material, but the match between the cathode material and the electrolyte needs to be considered in order to optimize the performance of a full cell. The reviewer is eager to check how the PI addresses this point when developing composite cathodes.

Reviewer 3:

The reviewer stated that several nano materials have been proposed and studied, but all of them seem to have the same problem; S dissolution is the common problem. Though publication is important, it is better to focus on one system and understand it well, rather than publishing several papers.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that the PI has recruited some collaborators with the expertise complementary to the PI, and has organized a productive, well-coordinated multidisciplinary research team.

Reviewer 2:

The reviewer commented that the PI has a good team.

Reviewer 3:

The reviewer remarked that the PI indicated no clear collaboration.

Question 4: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that the future plan has been well articulated, even though it still remains a challenge to develop a S cathode with a high density, and which is capable of excellent rate capability while maintaining good cyclic stability. To conduct research toward this direction is interesting.

Reviewer 2:

The reviewer said that the PI's future plan is sound.

Reviewer 3:

The reviewer commented that the volumetric efficiency should be a focus of the future work, and that the cycle life and failure mechanisms of balanced full cells, for example, without the unlimited supply of Li, should also be investigated and reported.

Reviewer 4:

The reviewer explained that the proposed future work describes the issues to be addressed, but the main challenge of preventing the active S species from diffusing into the electrolyte, is not addressed. This is critical for the future use of S cathode.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer said that the ongoing research is well aligned with the mission and the objective of DOE program.

Reviewer 2:
The reviewer explained that although this S battery project is still basic in nature, the information learned may help solve the inherent issues know in Li-S sulfur batteries.

Reviewer 3:
The reviewer noted that this technology will help in reducing the use of petroleum.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer stated that adequate recourses have been allocated.

Reviewer 2:
The reviewer noted that the resources are sufficient.

Reviewer 3:
The reviewer remarked that no further comments are needed.

High Energy Density Lithium Battery: Stanley Whittingham (Binghamton University) - es231

Presenter

Stanley Whittingham, Binghamton University.

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

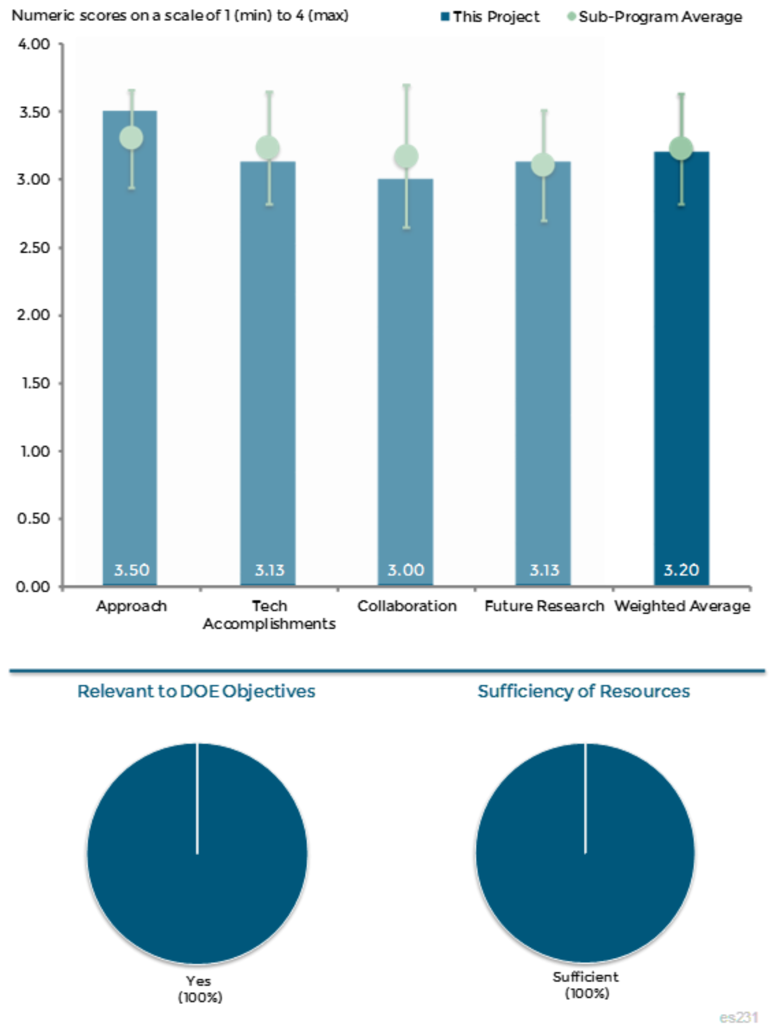


Figure 2-48 High Energy Density Lithium Battery: Stanley Whittingham (Binghamton University) - Electrochemical Energy Storage

Reviewer 1:

The reviewer commented that it is good to see some creative approaches to high-energy density, and refreshing that the choices were made as alternatives to Si anodes and nickel rich intercalation cathodes. The project is in its early days, but it has a good start to begin to understand some of the interesting alternatives.

Reviewer 2:

The reviewer remarked that the approach in this project is outstanding. The research conducted may potentially result in new anode and cathode to replace current carbon anode and cathodes.

Reviewer 3:

The reviewer pointed out that project team's approach has innovative concepts to potentially overcome traditional barriers, but much testing and evaluation is needed to show how barriers are to be overcome. The approach could include HQ nano-Si materials as an alternative anode technology, where HQ would provide the materials, and that clear goal to achieve 300 Wh/kg and low-cost.

Reviewer 4:

The reviewer stated that the critical problem for copper (II) fluoride (CuF_2) is the dissolution and migration of copper (Cu) which results in fast capacity decay. The PI should focus on this critical problem. This reviewer added that M-Sn-C alloys have been investigated for Li-ion battery anode, although the innovation of this study is not clear.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:
The reviewer said that the technical achievement is excellent for this project so far.

Reviewer 2:
The reviewer noted that project is in its early days, but the progress appears appropriate for the time period.

Reviewer 3:
The reviewer commented that progress has a long way to go in showing how classical barriers are overcome by these new materials. Overall strategy is robust in that both intercalation and conversion materials are considered.

Reviewer 4:
The reviewer described that the PI should focus on critical challenges of CuF_2 dissolution and aggregation, for Sn-iron (Fe)-C alloys, dissolution of SEI may contribute the capacity if the alloys are charged and discharged in the tin 0.0-3.0 V window, and added that because the PI did not provide the charge and discharge curve, it is hard to evaluate. The high-irreversible capacity is another issue for ball-milled Sn-Fe-C alloys.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer stated that the PI has appropriate technical collaborations to achieve the project objectives. Involvement with New York Battery and Energy Storage Technology Consortium (NYBEST) is unique and could result in more collaboration and funding.

Reviewer 2:
The reviewer noted that the PI is collaborating with the scientists in Brookhaven National Laboratory (BNL), ANL and NYBEST.

Reviewer 3:
The reviewer said that again, the project is in its early development. Collaboration will be more important as development moves into more complex materials development and into more complex cell configurations.

Question 4: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer commented that proposing the innovative materials is a good strategy, bit it has to be backed up by extensive and convincing testing.

Reviewer 2:
The reviewer stated that it will be interesting if there is an impact of electrolyte at higher temperature to cycle-ability with the CuF2 electrode, and if a failure modes study such as structure change of electrode materials, can be included in the future research plan.

Reviewer 3:
The reviewer noted that the capacity decay mechanism should be investigated for $CuFe_2$.

Question 5: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer stated that alternative high-capacity anodes and cathodes are important activities in high-capacity cell development.

Reviewer 2:
The reviewer said that the project has a good potential to improve battery performance and broaden

Reviewer 3:
The reviewer stated that this project addressed the target set by DOE on energy storage and tried to attack the technical barriers to increase battery energy density and reduce cost.

Reviewer 4:
The reviewer noted that the research fit the DOE goal.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer said that more resources will be necessary in a more mature state.

Reviewer 2:
The reviewer stated that the PI has the required capability to conduct proposed research.

Reviewer 3:
The reviewer stated that project's resources are currently adequate.

Electrode Fabrication and Performance Benchmarking: Vincent Battaglia (Lawrence Berkeley National Laboratory) - es232

Presenter

Vincent Battaglia, Lawrence Berkeley National Laboratory.

Reviewer Sample Size

A total of four reviewers evaluated this project.

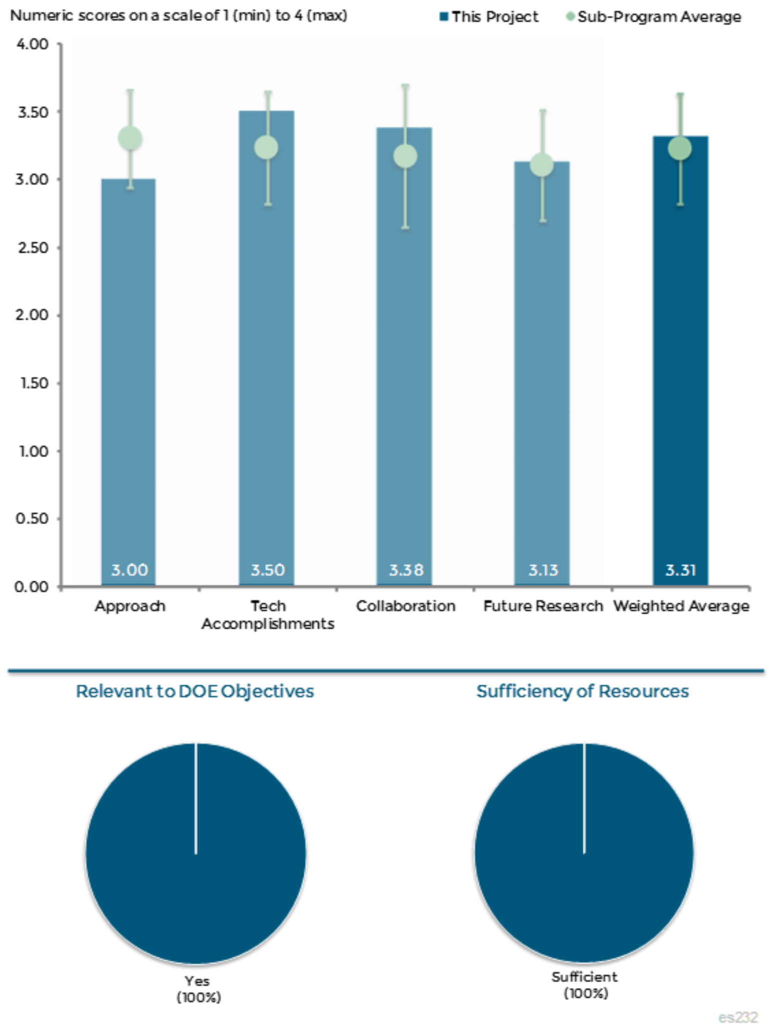


Figure 2-49 Electrode Fabrication and Performance Benchmarking: Vincent Battaglia (Lawrence Berkeley National Laboratory) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer pointed out that the PI optimized the electrode components and processing to achieve high-energy density and cycle life.

Reviewer 2:

The reviewer commented that the approach of this project is to provide quality electrodes and determine the electrode failure mechanism.

Reviewer 3:

The reviewer stated that it is important to have an independent capability to build electrodes and cells as a third-party independent evaluation of material capability. There is much good work here but perhaps a little unfocused as to supporting a clear charter or mission.

Reviewer 4:

The reviewer noted that approach demonstrated the test for various quality electrodes and their failure mechanism.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer remarked that again, the approach has some very interesting and wide-ranging data. The downside is that it perhaps lacks a bit of clarity on an overall objective.

Reviewer 2:
The reviewer explained that the reference position outside the anode and cathode cause abnormal impedance for anodes. The PI should validate if the electrochemical impedance spectroscopy (EIS) sum of the anode and cathode should be equal to the EIS of the two-electrode full cell.

Reviewer 3:
The reviewer expressed the need to know if there are any other physical and chemical means that can be used to determine a failure mechanism in addition to impedance and charge and discharge testing.

Reviewer 4:
The reviewer expressed the need to understand why lithium iron phosphate (LFP) electrodes cannot be made for 0.8 mAh/cm^2 without cracks, and that failure mechanisms should be further examined.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer stated that the project team has a good collaboration and interaction.

Reviewer 2:
The reviewer noted that this work is collaborative.

Reviewer 3:
The reviewer said that the work relies on expanded collaboration within existing programs to evaluate materials early in the development program and to allow for benchmarking of the progress of advanced materials.

Question 4: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer observed that Slide 36 summarizes all the issues to be addressed, and that this project should be further continued in order to understand the failure mechanism.

Reviewer 2:
The reviewer expressed a need to know if there are any alternative solutions to the challenges and barriers identified in this project.

Reviewer 3:
The reviewer commented that not much work can be done during the three remaining months.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer stated that optimization of the cell is also important for the full use of the electrode materials.

Reviewer 2:
The reviewer said that this project provided quality materials to support the BMR program.

Reviewer 3:
The reviewer noted the project work will reduce the use of petroleum.

Reviewer 4:

The reviewer expressed an agreement with the concept of an independent capability to build and evaluate cells with small materials amounts.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer observed that the PI can do the proposed work at LBNL.

Efficient Rechargeable Li/O_2 Batteries Utilizing Stable Inorganic Molten Salt Electrolytes: Vincent Giordani (Liox) - es233

Presenter

Vincent Giordani, Liox.

Reviewer Sample Size

A total of three reviewers evaluated this project.

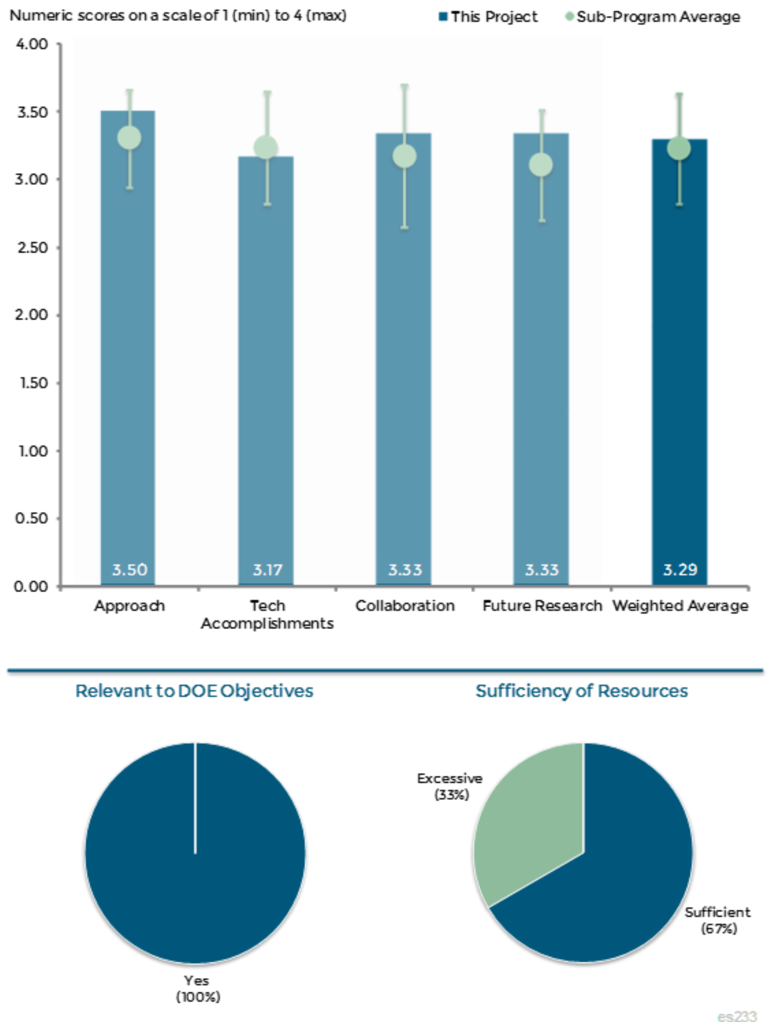


Figure 2-50 Efficient Rechargeable Li/O2 Batteries Utilizing Stable Inorganic Molten Salt Electrolytes: Vincent Giordani (Liox) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer reported that this project is addressing a key issue with Li-air systems, and that is the formation of non-reversible Li salts. The project team has developed a strong testing protocol to help with the characterization efforts, and has shown the ability to detect and characterize the key impurities and products. The reviewer commented that a bit more background on the topic would help in future presentations.

Reviewer 2:

The reviewer stated that the PIs explored the use of a molten salt electrolyte for Li-air batteries, and that the electrochemical stabilities and thermo-characteristics of the electrolytes were investigated. Li peroxide (Li_2O_2) and O_2 solubility and diffusion coefficients were also measured, and the Li-air performance was tested. The reviewer added that the approaches are solid and aim to understand the fundamental aspects of O2 redox reaction in molten salt.

Reviewer 3:

The reviewer noted that the project team has an interesting approach to solving the rechargeability problem in the Li/O_2 system.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer reported that there was a significant drop in transference with the eutectic electrolytes and this could be a significant issue. At this point, the project to appears to have been running a large number of characterization tests, and while appropriate, it is unclear if the full battery work was necessary before material choices had been narrowed down. The reviewer observed that all project milestones have been hit to date though to this point, there has been little novel work. One can understand that most of the work to this point involved set-up, and it will be curious to see how future work develops. The reviewer went on to say that it was quite interesting to see how with precise O_2 measurement, the team was able to measure the number of electrons.

Reviewer 2:

The reviewer explained that the PIs accomplished the milestones on time and that the critical aspects of the systems were investigated. However, the electrochemical results, for example, the high round-trip efficiency, need to be confirmed with gas analysis in order to make sure that the oxidation reaction was indeed the oxidation of Li_2O_2. The reviewer added in addition, because the solubility of O_2 and Li_2O_2 are so low in the molten salt, the PIs need to comment on the rate of the reaction (charge and discharge rate).

Reviewer 3:

The reviewer stated that more emphasis should be made on studying compatibility of all cell components with the molten salts, and that it would be interesting to see an assessment of the volumetric energy density on a system level for the proposed system verses the original electrolyte system.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that the collaboration with LBNL and Caltech demonstrates a strong coordination of the research. It seems such collaboration could result in more results, for example, the proposed in-situ gas analysis.

Reviewer 2:

The reviewer noted that collaborators are best in this research area.

Reviewer 3:

The reviewer said that the collaborations with Lawrence Berkeley National Laboratory (LBNL) and Caltech are appropriate, and that given the early status of the technology, it would be important to have discussions with the wider Li-air community but something formal is not expected.

Question 4: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that the set-up of the testing sensor bodes are well used for the expedited development of a non-carbonaceous electrolyte for Li-air, though a more detailed plan on this would have been appreciated. The project team has good eye-to-technology commercialization, which should help ensure the impact after the research is completed. The reviewer added that there needs to be focus on the impact of this work on the full system metrics.

Reviewer 2:

The reviewer commented that it will be beneficial to add a task on studying the Li anode and the molten electrolyte system for the rechargeable Li systems.

Reviewer 3:

The reviewer said that the proposed future work for non-carbon electrode selection and management of Li_2O_2 dissolution and precipitation are in a solid direction. The reviewer suggested that the-co-PI in LBNL should do more analytical investigation to understand the true nature of the redox reaction.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer said that the project has a potential to benefit Li-based rechargeable systems.

Reviewer 2:

The reviewer stated that the development of higher energy density, lighter weight, and longer cycle life batteries would accelerate the electrification of the transportation sector.

Reviewer 3:

The reviewer noted that the research is very relevant to the DOE goal.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer noted that the PIs have adequate resources for the research.

Reviewer 2:

The reviewer pointed out that about one-third of the project's budget has already been spent while one-sixth of the project is complete. This observation merited a discussion and that an explanation would have been appreciated.

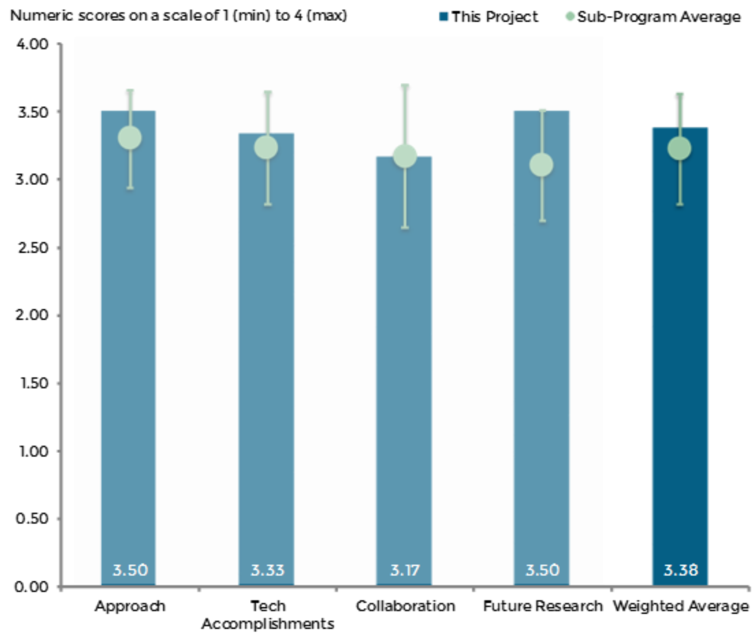
Continuum Modeling as a Guide to Developing New Battery Materials: Venkat Srinivasan (Lawrence Berkeley National Laboratory) - es234

Presenter

Venkat Srinivasan, Lawrence Berkeley National Laboratory.

Reviewer Sample Size

A total of three reviewers evaluated this project.



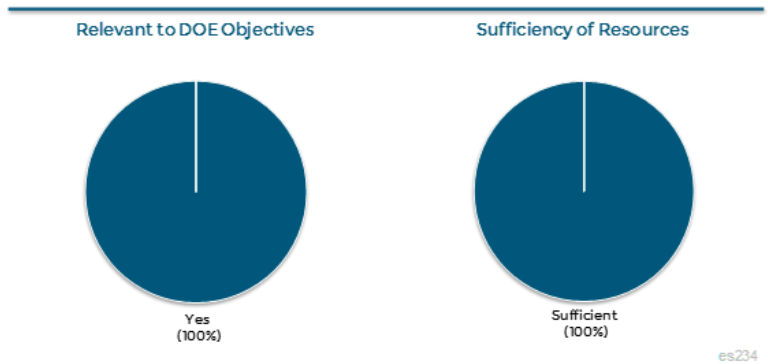


Figure 2-51 Continuum Modeling as a Guide to Developing New Battery Materials: Venkat Srinivasan (Lawrence Berkeley National Laboratory) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer said that the PI has an excellent approach where relevant problems are attacked in a number of areas important to advanced battery development.

Reviewer 2:

The reviewer explained that the combination of x-ray tomography with three-dimensional (3D) microstructure simulations will lead to promising new insights. The reviewer expressed the need to know if microstructure change due to aging will be included in the future work.

Reviewer 3:

The reviewer noted that approach has a good marriage between modeling and experimental work.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer remarked that project team has excellent progress towards improving the model through a careful and deep understanding of the input parameters.

Reviewer 2:

The reviewer stated that the simulation work at cell level for the Li-S battery is inspiring. More discussions on the over-all energy density at the cell level, not just energy density normalized by active materials, can help the decision making for vehicle development.

Reviewer 3:
The reviewer expressed that a number of the PI's results were quite interesting, especially favoring the PI’s conclusions about Li conducting glasses.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer stated that the PI has several collaborations, but almost all of them are within his laboratory.

Reviewer 2:
The reviewer commented that good collaboration is that best blend of theoreticians and practitioners.

Question 4: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer observed that the PI plans to continue the project’s present development and to extend its studies into new areas.

Reviewer 2:
The reviewer said that future work includes broad selections of systems and tools.

Reviewer 3:
The reviewer expressed to know what the follow up work is for Si and binder simulation.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer commented that this project could lead to a broad range of advanced battery improvements. Ultimately, this will lead to reduced battery costs enabling further electrification of the nation's vehicles and improved gas mileage.

Reviewer 2:
The reviewer noted that the project provides a deep understanding and guidance for the potentially high-energy systems.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer explained that there is quite a bit of work left in the project and the effort seems appropriately funded. However, the reviewer expressed a misunderstanding of why a 0.1 full-time equivalent (FTE) staff scientist and a 1.5 FTE postdoctoral scholar cost $430,000 per year, even at a national laboratory.

Reviewer 2:
The reviewer noted that resources included that right blend of experts.

Energy Storage Materials Research Using DOE's User Facilities: Michael Thackeray (Argonne National Laboratory) - es235

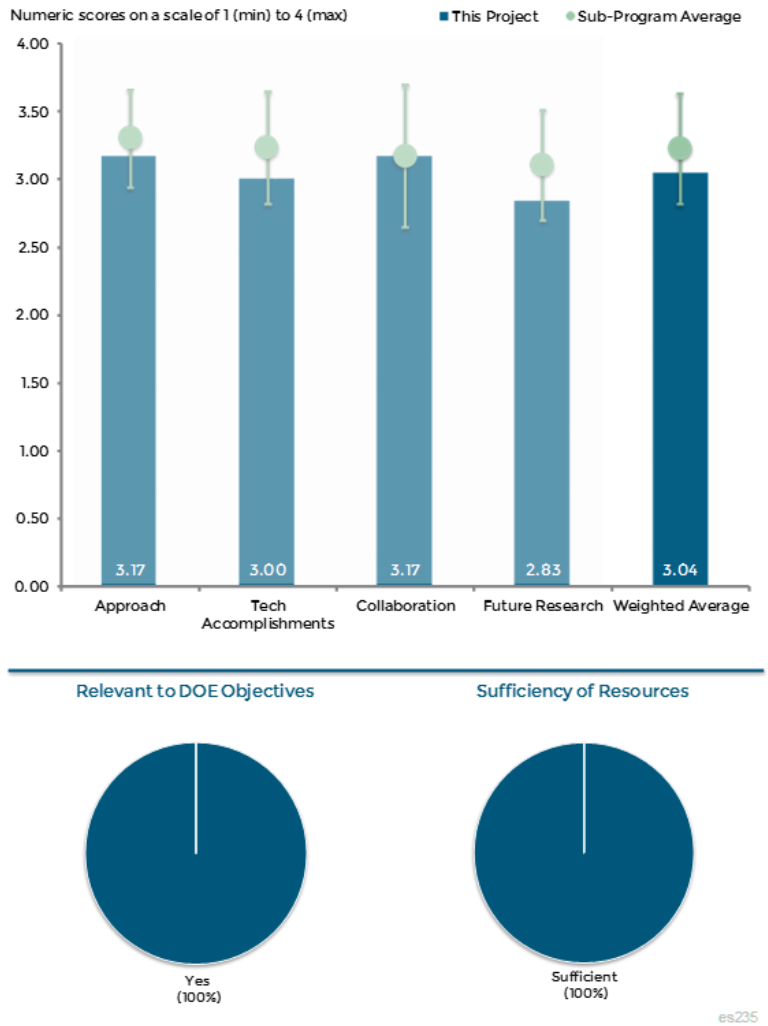


Figure 2-52 Energy Storage Materials Research Using DOE's User Facilities: Michael Thackeray (Argonne National Laboratory) - Electrochemical Energy Storage

Presenter

Jason Croy, Argonne National Laboratory.

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that the approach of using multiple diagnostics techniques to understand the behavior of high-energy cathodes is excellent. The team uses high-resolution X-ray diffraction crystallography (XRD), neutron diffraction, XAS, electron microscopy and other techniques.

Reviewer 2:

The reviewer observed that the PIs used different characterization technologies to investigate the structure-property relationship.

Reviewer 3:

The reviewer remarked that the characterization tests being conducted are sufficient to understand electrode design, and that it will be interesting to see if any of the models will be able to predict better structures. The reviewer is concerned about the titling of this project as a user facility. It does not appear there was a large number of users outside of ANL.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer stated that there have been significant characterization studies undertaken by this project and that on the whole, the PowerPoint was well done and the insights from the project were well communicated.

Reviewer 2:
The reviewer reported that the results are good, but wondered if one could focus more on the issues that impede the layered/layered cathodes from reaching commercial acceptance (e.g., low SOC impedance, poor packing density, etc.). This comment is not solely focused on this project, but rather applies to many of the diagnostics efforts in the program.

Reviewer 3:
The reviewer observed that there was lack of coordination on different technologies for after few year study, no solid conclusions were made. Only that the design space is large and complex.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer commented that the project team has a very good list of collaborators.

Reviewer 2:
The reviewer said it is a team work.

Reviewer 3:
The reviewer said that while there is a significant number of collaborators, there is concern that there is no engagement of private sector companies. For reference, it would be helpful to also have some industry produced material standards.

Question 4: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer commented that the PIs should focus on understanding the mechanism using different characterization technologies, and then design the electrode materials.

Reviewer 2:
The reviewer reported that as this project is nearly completed, there is some concern about the ability to accomplish the tasks laid out in future work. The reviewer expressed if this work is already underway and will it just be completed during the next quarter. The long term impact on electrode design considerations could be substantial after this work is completed, and it will require broader engagement of the research community.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer said that the project's development of better cathodes either through material work or processing work, directly improves the performance of batteries. It is this that limits the performance.

Reviewer 2:
The reviewer noted that this work fits in with the DOE goal to reduce GHG emissions.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer commented that project team's work is a good value for the budget, with excellent progress and data.

Reviewer 2:
The reviewer observed that the PIs have the resources to do the work.

Reviewer 3:
The reviewer noted that the funding is sufficient for this work.

Crash Propagation Simulations and Validation: Shriram Santhanagopalan (National Renewable Energy Laboratory) - es236

Presenter

Shriram Santhanagopalan, National Renewable Energy Laboratory.

Reviewer Sample Size

A total of two reviewers evaluated this project.

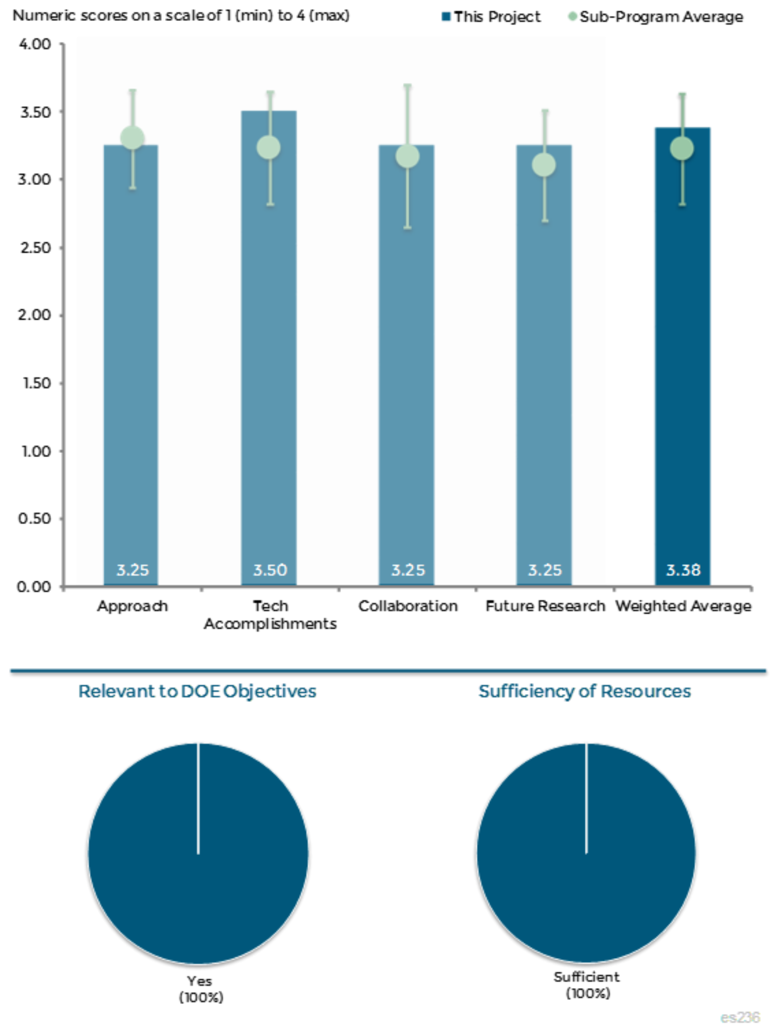


Figure 2-53 Crash Propagation Simulations and Validation: Shriram Santhanagopalan (National Renewable Energy Laboratory) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that the approach is good and the modeling of the actual predicted cell deformation is anticipated to provide better failure mode identification capability. The reviewer posed the question whether an electro-chemical aspect to the multi-domain modeling should be considered.

Reviewer 2:

The reviewer noted that it is hard to see how the funds support the effort.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer explained that the PIs have demonstrated the logic path moving from the mechanical deformation to the electro-thermal response, and have combined this with experimental validation to support the results.

Reviewer 2:

The reviewer commented that the technical accomplishments have been achieved as planned.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer said that the project team’s collaboration roles and effort appears to be well defined.

Reviewer 2:
The reviewer inquired if it is possible to leverage the efforts of other projects to save the efforts in validation.

Question 4: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer remarked that it might be a good idea to at least consider a framework for incorporating the electro-chemical aspect of the problem into the simulation platform. The reviewer asked if a full battery pack damage demonstration test will be considered as full validation of the approach.

Reviewer 2:
The reviewer asked if it is possible to include the study of the impact of battery management systems (BMS) and thermal system on the crash propagation in the future research.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer stated that the development of predictive modeling capabilities for battery damage will enable the design of more damage-tolerant systems.

Reviewer 2:
The reviewer noted that the project predicts battery safety during crash and can potentially help the battery design.

XG Sciences: Development of Silicon Graphene Composite Anode: Robert Privette (XG Sciences) - es237

Presenter

Robert Privette, XG Sciences.

Reviewer Sample Size

A total of three reviewers evaluated this project.

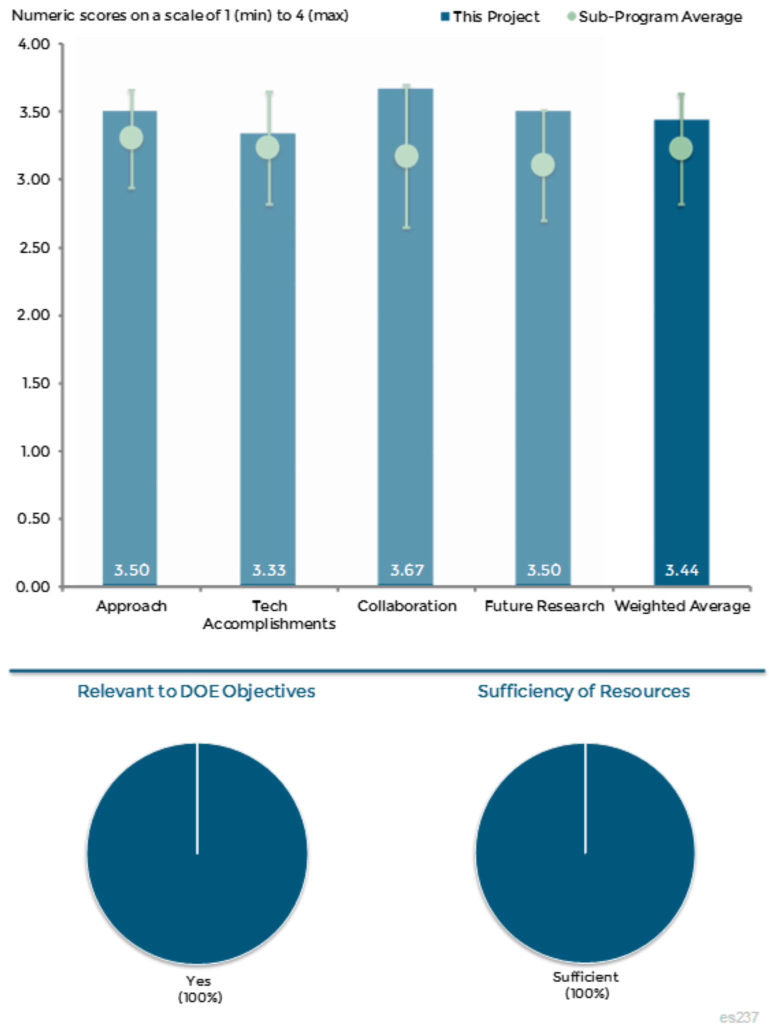


Figure 2-54 XG Sciences: Development of Silicon Graphene Composite Anode: Robert Privette (XG Sciences) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that the graphene and silicon composite will produce advanced anodes for Li-ion batteries and manufacturing process is being developed.

Reviewer 2:

The reviewer explained that it seems the two major components to this project are materials development and process scale development. Slide 11 shows a material and cell that meets the 500 cycle milestone goal, but Slide 12 shows a next generation technology that in regards to DOE, does not meet the goal even in the coin cell. The reviewer remarked that the path to both scale-up and cycle life is not clear, and is also not sure about the use of the term graphene platelets. If the plates are multi-layered, then they are graphite platelets. The reviewer added that 600 mAh/g is among the lowest energy densities of the anode projects at the AMR, and 1,000 cycles to 80% retention would be a better goal. Also, just as a reference the USABC goals for EV batteries are 350 Wh/kg useable at end-of-life (EOL) plus 1,000 cycles of the full usable range, and that 1,000 cycles at 80% depth-of-discharge (DoD) will probably fall a little short of this goal. This is a 2020 goal and while it may not be applicable to this stage of the research, it is good to keep in mind if the end goal is the automotive environment.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer stated that the composite anode capacity is validated with the newly developed coating process.

Reviewer 2:

The reviewer said that in reference to above comments, though the GEN3 material is stable over a wider voltage range, the fact that it does not meet even the 500 cycles to 70% capacity retention, shows there are still significant technical barriers to overcome in this project. The reviewer expressed the need to see more information on the volumetric energy density of this material, as well as the rate capabilities.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer explained that the scale-up work at the A123 Systems and the ANL facility, is a big strength of this project.

Reviewer 2:

The reviewer noted that the involvement of high-volume global cell producer is the only area for possible improvement.

Reviewer 3:

The reviewer commented that the partners include the leading battery suppliers, component suppliers, and research laboratories.

Question 4: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that the future work will validate the manufacturing process and the cycle life.

Reviewer 2:

The reviewer commented that the project is on the right track, however, as mentioned in above comments there are still very significant technical challenges to overcome, and from the presentation slides, it is very difficult to see a path to doubling the cycle life of this material.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer noted that the high-energy anode will help with the penetrations of the EV acceptance.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer observed that the project seems worthy of greater resources.

Reviewer 2:

The reviewer stated that the money and resources seem sufficient.

Low-Cost, High-Capacity Lithium-Ion Batteries through Modified Surface and Microstructure: Pu Zhang (Navitas Systems) - es238

Presenter

Pu Zhang, Navitas Systems.

Reviewer Sample Size

A total of three reviewers evaluated this project.

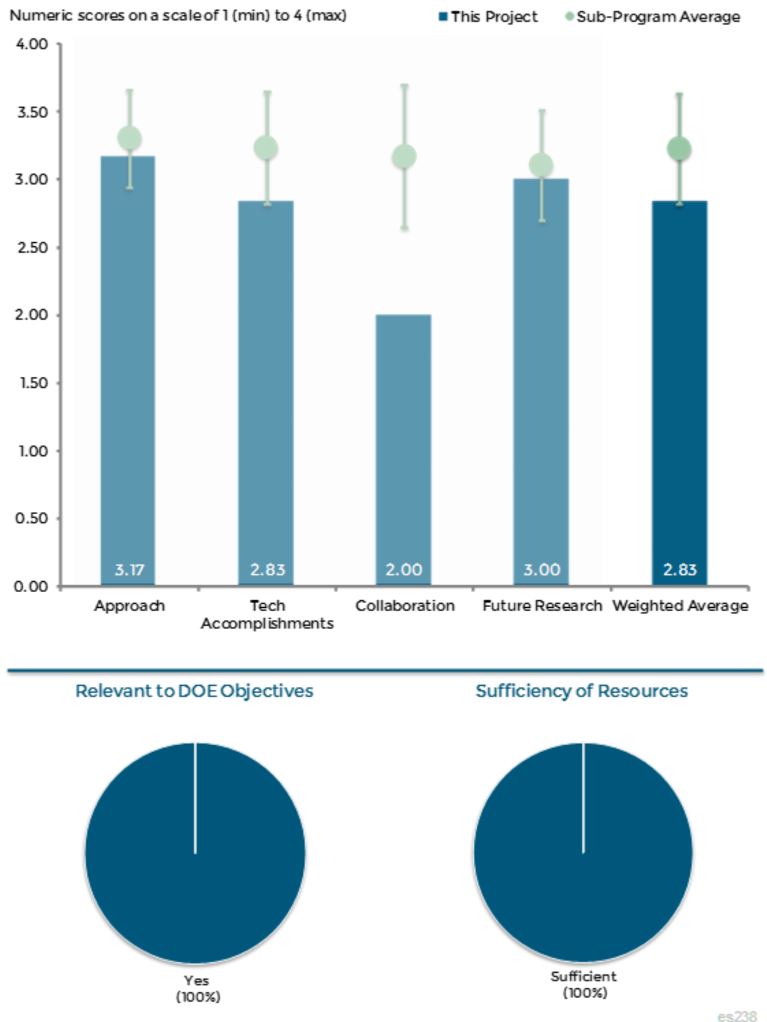


Figure 2-55 Low-Cost, High-Capacity Lithium-Ion Batteries through Modified Surface and Microstructure: Pu Zhang (Navitas Systems) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer explained that the approach of macro-porous Si with controlled pore structure to accommodate the large Si volume internal change, is a good approach.

Reviewer 2:

The reviewer explained that on Slide 8, using coin cells as proof of technology is a good preliminary step, but may not prove that this material has greater cycle life than a non-porous Si anode in a full cell configuration. Also very little information is given about the composition of each anode, so it is hard to make a technology assessment from this slide. The reviewer added that as shown on Slide 5, HF may not be the best method to use for etching unless one can fully remove the HF before using the material, which is surely already known, for HF is well known for contributing to degradation in Li-ion cells. On Slide 3 and 4, mAh/cm^2 is a large coating. The reviewer expressed a need to be worried about the rate performance of these electrodes as not being good enough for the automotive environment. Also, just as a reference, the USABC goals for EV batteries are 350 Wh/kg useable at EOL plus 1,000 cycles of the full usable range, and that 1,000 cycles at 80% DoD will probably fall a little short of this goal. The reviewer went on to say that this is a 2020 goal, and while it may not be applicable to this stage of the research, it is good to keep in mind if one's end goal is in the automotive environment.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer observed that GEN1 material has been developed with 800 mAh/g capacity and 15% initial capacity loss (ICL).

Reviewer 2:

The reviewer commented that on Slide 6, cycle life seems to be a large issue in this project, and noted that data showing that the phase-1 cycle life of 300 cycles at 100 percent DoD was met, could not be seen. In general, the title of the project contains the words low-cost, but any information or goals pertaining to cost anywhere in the slides, could also not be seen.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted that the planned collaboration with A123 Systems and Xalt Energy is satisfactory, bur project team also needs high-energy cathode collaboration.

Reviewer 2:

The reviewer commented that all of the work is being done by Navitas Systems as far as far as the reviewer could tell, and suggested collaborating with other partners, particularly when it comes to the artificial SEI work.

Reviewer 3:

The reviewer explained that A123 Systems and Xalt Energy are listed as possible partners, but it is unclear how and if they can and will support this project, or if they would be appropriate at this stage of development.

Question 4: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that pilot scale etching and SEI formation will help to validate the concept of using large format cells, and that the swelling of the cells needs to be monitored and with mitigation if necessary.

Reviewer 2:

The reviewer explained that on Slide 17, there was no mention in the project of improving cycle life, unless it is being alluded to by the SEI coating to improve the performance. Because there is no data in the project showing even 200 cycles to 80% capacity retention, the main focus of the future work has to be improving cycle life. The reviewer added that electrolyte may also play a large role in making this technology viable, but it is not mentioned at all in the future work.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer said that the advanced anode and high-energy cathode will improve the probability of EV applications which will reduce petroleum usage.

Reviewer 2:

The reviewer commented that the concept is very promising, but there is still a lot of work to be done to make a viable material for commercial use.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented that the funding resources that follow original proposal, is enough.

Scale-Up of Low-Cost Encapsulation Technologies for High-Capacity and High-Voltage Electrode Powders: David King (Pneumaticoat Technologies) - es239

Presenter

David King, Pneumaticoat Technologies.

Reviewer Sample Size

A total of three reviewers evaluated this project.

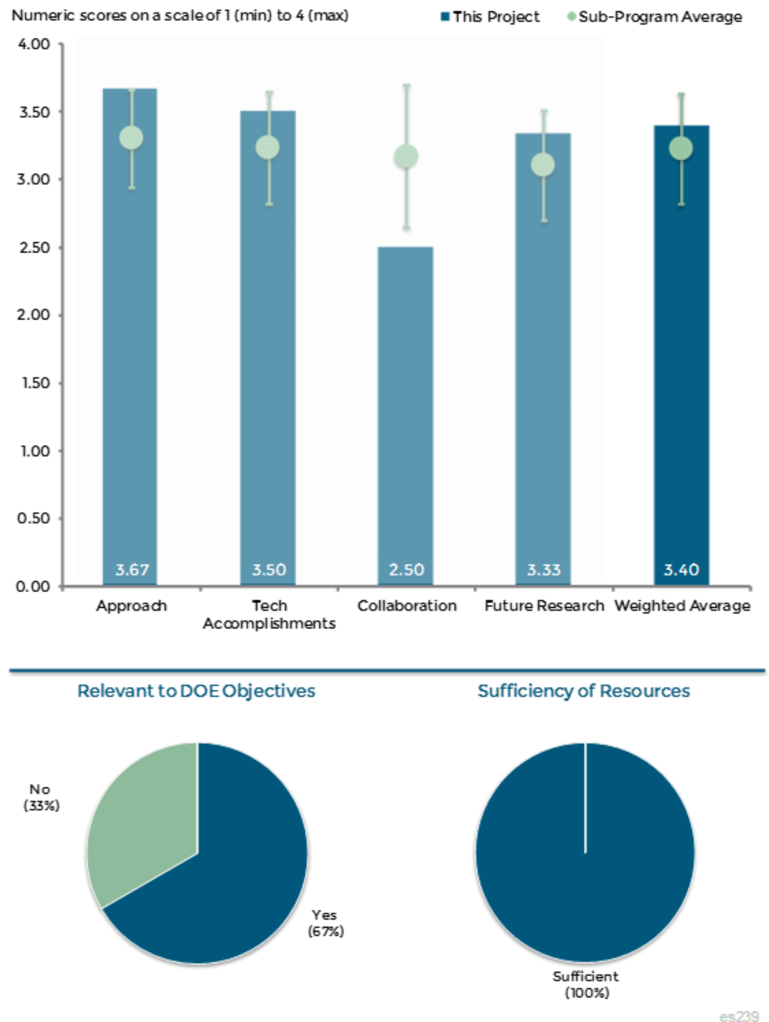


Figure 2-56 Scale-Up of Low-Cost Encapsulation Technologies for High-Capacity and High-Voltage Electrode Powders: David King (Pneumaticoat Technologies) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer reported that the ALD coating is beneficial to the stability of the anode and cathode in the electrolyte.

Reviewer 2:

The reviewer remarked that this is a very interesting project. Slide numbers would be helpful to the reviewers. In regards to the slide that shows ALD versus co-precipitation, this slide is hard to evaluate ALD 1 and ALD 2, and asked if these are the team's scaled up ALD processes or represent a more standard ALD process. The reviewer commented that if these not the team's scaled up ALD processes, then a test of the project's semi-continuous ALD process versus a lab scale ALD process, would be an important comparison. Referring to the slide that shows pouch cell ALD performance, the bottom says demonstrated performance but the slide indicates the testing is only to approximately 250 cycles. In all, the reviewer expressed that the technology is very interesting, but as a reviewer, it can be difficult to understand the presentation. Labels indicating whether the ALD coating was a standard batch process or your semi-continuous process would be helpful in evaluating the work.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer noted that the project team's down-select progress is appropriate.

Reviewer 2:
In reference to the above notes, the reviewer explained that it seems that a variety of materials have been tested, which is good, but this variety also confuses the ability to understand the progress of the technology. The data moves from NMC to LMR-NMC to LNMO/LTO, so it is hard to clearly see the progress from phase-1 to phase-2.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer noted that the Xalt Energy collaboration will lead to improve the battery cycle life and performance.

Reviewer 2:
The reviewer stated that there is not a slide explicitly showing the collaboration with other institutions, but reading between the lines, it seems that good collaboration is taking place with materials suppliers and cell manufacturers.

Question 4: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer explained that a study with one material, or even two different materials and coatings, that show the cycle life of the uncoated material, the batch ALD coated material, the team’s semi-continuous ALD coated material, and the ALD coated electrodes with all other things held constant, would be a good way to more clearly show the progress and viability of the research. More cost data would also help evaluate if the technology is economically viable.

Reviewer 2:
The reviewer stated that the planned system reliability and electrochemical reproducibility studies using 200 kg of cathode powders will provide the need for a quality coating for battery suppliers.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer remarked that yes, the project supports the DOE goals, and if this technology is successful, it will be an excellent technology for coating electrode materials for mass production.

Reviewer 2:
The reviewer said that the improvement in cell longevity will provide the cost reduction per cycle and will help with petroleum displacement.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer stated that project team has excellent progress considering budget size.

Reviewer 2:
The reviewer noted that the resources are good enough for coating studies.

Development of Silicon Graphene Composite Anode: Samir Mayekar (Sinode Systems) - es240

Presenter

Cary Hayner, Sinode Systems.

Reviewer Sample Size

A total of three reviewers evaluated this project.

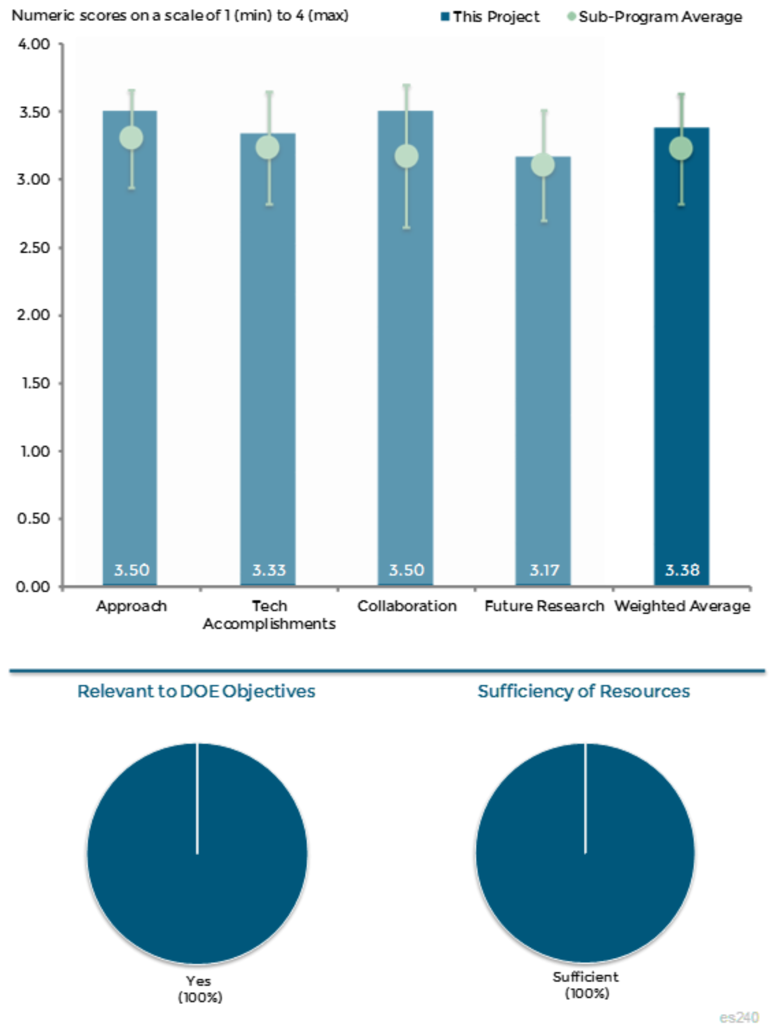


Figure 2-57 Development of Silicon Graphene Composite Anode: Samir Mayekar (Sinode Systems) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that the 3D graphene structure will help with Si insertion to improve anode capability.

Reviewer 2:

In reference to Slide 3, the reviewer stated that an anode of 750 to approximately 1,500 mAh/g leading to a 200 Wh/kg cell in regards to DOE, does not seem quite right, for the cell goal should be closer to 300-350 Wh/kg. Also, just as a reference, the USABC goals for EV batteries are 350 Wh/kg useable at EOL plus 1,000 cycles of the full usable range, and that 1,000 cycles at 80% DoD will probably fall a little short of this goal. The reviewer added that this is a 2020 goal, and while it may not be applicable to this stage of the research, it is good to keep in mind if the end goal is the in the automotive environment. The reviewer went on to say that in Slide 5, the approach is very novel and quite interesting, but is not sure how the holey-graphene material is produced and if it is tailorable for holey-ness.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer remarked that the project team has outstanding work, particularly with the given budget.

Reviewer 2:

The reviewer commented that Slides 8 to 12 showed the various areas of focus, materials sourcing, composition, etc., leading to improvements in the cycle life of the material. However, there is still significant process to be made to reach the cycle life goal. In reference to Slide 14, some binding agent may be needed in order to keep the electrode attached to the current collector, where Slide 5 mentions that minimum inactive material is used in the anode formulation.

Reviewer 3:
The reviewer explained that the failure modes are identified and mitigation using coating, additives, etc., is planned.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer said that in Slides 10 and 11, the project team's collaborations with other institutions is good particularly in the area of materials analysis.

Reviewer 2:
The reviewer remarked that the project team has excellent collaboration and partners, where the only improvement could be to have involvement of a leading international cell manufacturer.

Reviewer 3:
The reviewer noted that collaboration with the university, material supplier, and the cell builder will expedite the development.

Question 4: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer commented that on Slide 17, the approach to the research is very good. The biggest challenge for this work to meet the DOE goals is to improve the cycle life, and that some more focus on methods to improve the cycle life should be included in this slide or else it is hard to see a path to meet these goals. Scale-up work is also very important and not covered in very much detail in the presentation. The reviewer added that while this is primarily an anode program, the goals are on the cell level, so some electrolyte work may be necessary in order to meet the goals.

Reviewer 2:
The reviewer noted that the failure modes are identified and the mitigation using coating additives, etc., is planned.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer commented that the advanced anode will reduce the cost of the batteries and will help with electrification of automobiles.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer remarked that he $500,000 should be sufficient to meet the planned progress.

A Disruptive Concept for a Whole Family of New Battery Systems: Farshid Roumi (Parthian Energy) - es242

Presenter

Farshid Roumi, Parthian Energy.

Reviewer Sample Size

A total of three reviewers evaluated this project.

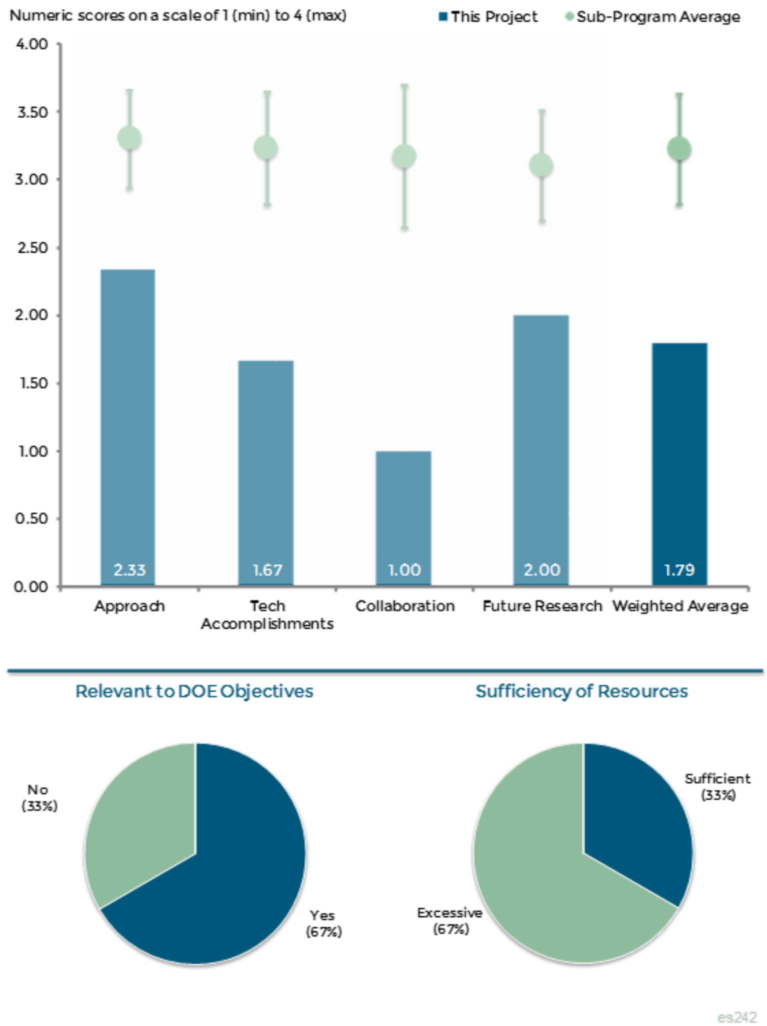


Figure 2-58 A Disruptive Concept for a Whole Family of New Battery Systems: Farshid Roumi (Parthian Energy) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commented that the Li wire anode and Si anode's hybrid concept may be an acceptable approach.

Reviewer 2:

The reviewer commented that this work is in its preliminary stages, so it is difficult to review. In reference to Slide 3, 450 Wh/kg is a very aggressive goal, however, 500 cycles is not, plus there is no capacity retention specified. The reviewer expressed that a reasonable goal should be more like 700-800 cycles at 80% DoD to 80% capacity retention. If there is no path to do this, then scalable fabrication would be a waste. The reviewer also expressed a need to see a goal in terms of Wh/liter (L). In reference to Slide 5, the photos are not showing a fabrication method.

Reviewer 3:

The reviewer asked if the current collection of designs is for anode or cathode, separator tube fabrication, current distribution in cathode plate, and electrolyte retention and distribution.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer commented that in Slide 7, more information is needed on this slide, and asked where the cycle method and rate was, and if this is really a copper-$LiCoO_2$ cell or is Cu the current collector. There is a large gap to fill in terms of cycle life in this project. The reviewer also asked how the team will know if this technology will cycle, and what the plan is for a separator. In Slide 9, there is no proof of concept in this photo. The reviewer asked for data. The reviewer also questioned the schedule on Slide 12, where it is hard to evaluate the state of the research without knowing where to look in the deliverables schedule, and where the referenced 5 Wh cells fit into the deliverables.

Reviewer 2:

The reviewer noted that the demonstration of the concept with a cathode is not shown.

Reviewer 3:

The reviewer remarked that the project's progress is either poor or there is not enough detail to judge.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that there is no collaboration with a cell manufacturer.

Reviewer 2:

The reviewer observed that no evidence of project team's collaboration is given.

Reviewer 3:

The reviewer noted that the project team's collaboration is either none or unknown.

Question 4: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer commented that it was very difficult to determine the project team's future research.

Reviewer 2:

The reviewer pointed out that in Slide 13, a 50-mile PHEV needs about 14.5 kWh of usable energy with approximately 95% to 25% SOC, which means that the actual cell needs to be about 30% larger. The reviewer expressed a need to know what the power capability of this cell is, and if it is 100kW as needed for a PHEV. Cycle life is a major concern, and there is not a clear path in the future work toward improving the cycle life.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that if successful, this project could be a high-reward program. However, there are many risks and challenges which are not well represented in this presentation.

Reviewer 2:

The reviewer commented that it was not made very clear how the cost of the cells and energy is improved.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer observed that it seems this project is more like a science experiment in a lab and, therefore, may not need $75,000.

Dramatically Improve the Safety Performance of Lithium-Ion Battery Separators and Reduce the Manufacturing Cost using Ultraviolet Curing and High Precision Coating Technologies: John Arnold (Miltec UV International) - es243

Presenter

John Arnold, Miltec UV International.

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

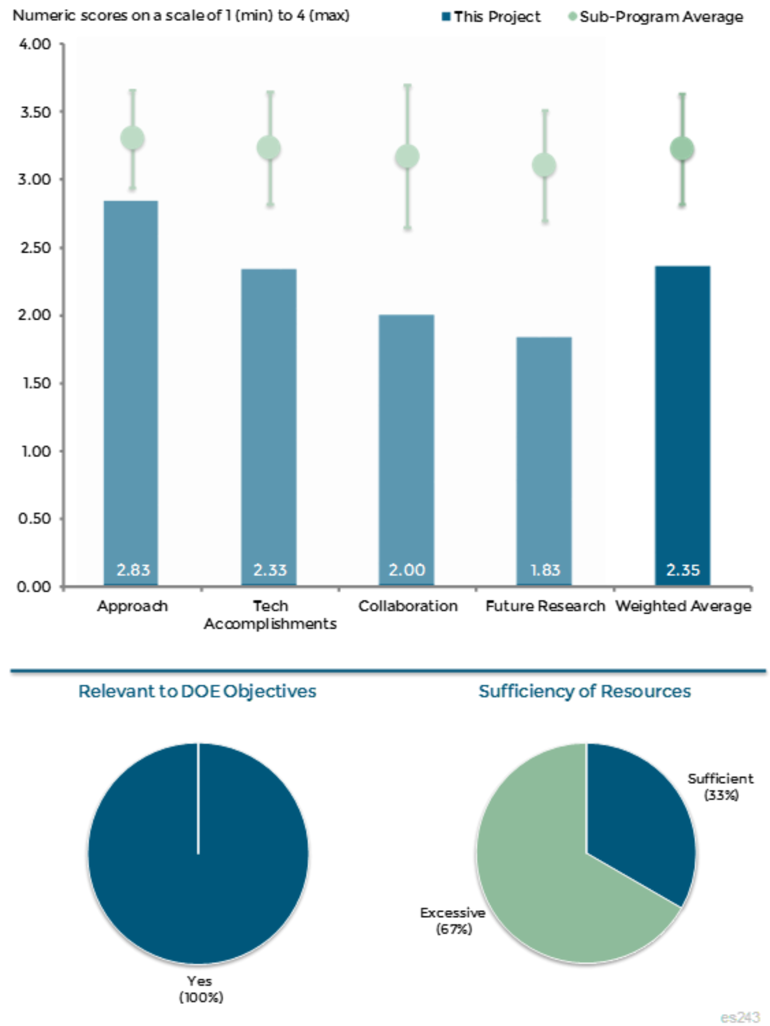


Figure 2-59 Dramatically Improve the Safety Performance of Lithium-Ion Battery Separators and Reduce the Manufacturing Cost using Ultraviolet Curing and High Precision Coating Technologies: John Arnold (Miltec UV International) - Electrochemical Energy Storage

Reviewer 1:

The reviewer stated that this approach is very interesting and relevant technology, and expressed a need to see more information about the resultant separator. See USABC separator goals as an example of important properties.

Reviewer 2:

The reviewer stated that any ceramic coating will improve the high-temperature stability of Li-ion separators.

Reviewer 3:

The reviewer explained that it is difficult to discern how this specific approach compares in terms of performance of benefits and disadvantages to other ceramic separator coating methods. The comparison of shrinkage of base film of a given thickness, to coated form of same given thickness base film with additional thickness from the included coating, seems inappropriate. The reviewer also noted that the ceramic coated base film that is patterned or otherwise, shows less shrinkage than the same uncoated base film, and this hardly seems like an advancement over the state of the art. The reviewer expressed a need to understand where the result is of a simple electrochemical stability analysis performed on just a small sample of the coated separator which is coated at the noted line speeds. The ability to coat patterns in transverse direction (TD) or machine direction (MD) coating and effect on shrinkage in TD or MD coating should be the major highlighted benefit if the potential stability issues with UV package could be assumed to be negligible.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer explained that the shrinkage at 150°C should be less than 5% for an effective internal short prevention.

Reviewer 2:

The reviewer commented that just for the future, slide numbers make it easier to give clear comments. Regarding the slide entitled "Why ceramic coated separators?", the reviewer inquired if the project team is sure increasing the ion path tortuosity is really a plus. High-voltage stability is a good goal, but there no evidence of this is in the presentation, nor does the reviewer see any plans to test for it. In reference to the slide "Novel Printed Patterns," the reviewer said that this is interesting, but is not sure it is a good use of resources with so many fundamental questions unanswered. The reviewer would focus on whether the team's material can meet the state of the art, or the USABC goals, before working on patterns. In reference to the slide UV ceramic coating on tri-layer, the slide has no meaning without a control, and also, 50 cycles are not enough. The reviewer asked how the project team knows the integrity of the coating is good. In reference to the slide shut down pattern, the reviewer asked if the electrochemical stability of the team's shutdown coating is cycle life data or rate data of separators coated with the shutdown coating. In general, the process cost is missing, which is an important part of this work.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer said that it should be good that a major separator manufacturer is involved.

Reviewer 2:

The reviewer commented that based on the cover page, one can assume some project collaboration is taking place, but no information is given in the slides.

Question 4: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer explained that as mentioned above, there are still many unanswered questions about this technology which are not addressed in the presentation. In fact, there is not a slide addressing the future work at all, except on the slide with high-level milestones. The reviewer would like to see a lot more information about the properties of the separator or plans for testing the properties, if it has not been done yet.

Reviewer 2:

The reviewer said that the project has limited and ambiguous info regarding future research plan.

Reviewer 3:

The reviewer stated no clear path to improve high temperature shrinkage is identified.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that the safety of cells will improve the probability of using the cells for an automotive application.

Reviewer 2:

The reviewer remarked that this coating method has a potential to decrease the cost of coating separators, but there are currently many unanswered questions in the project.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer reported that $2 million for the separator coating is excessive and that the coated separators are available in domestic market.

Low-Cost, High-Capacity Non-Intercalation Chemistry Automotive Cells: Alex Jacobs (Sila Nanotechnologies) - es244

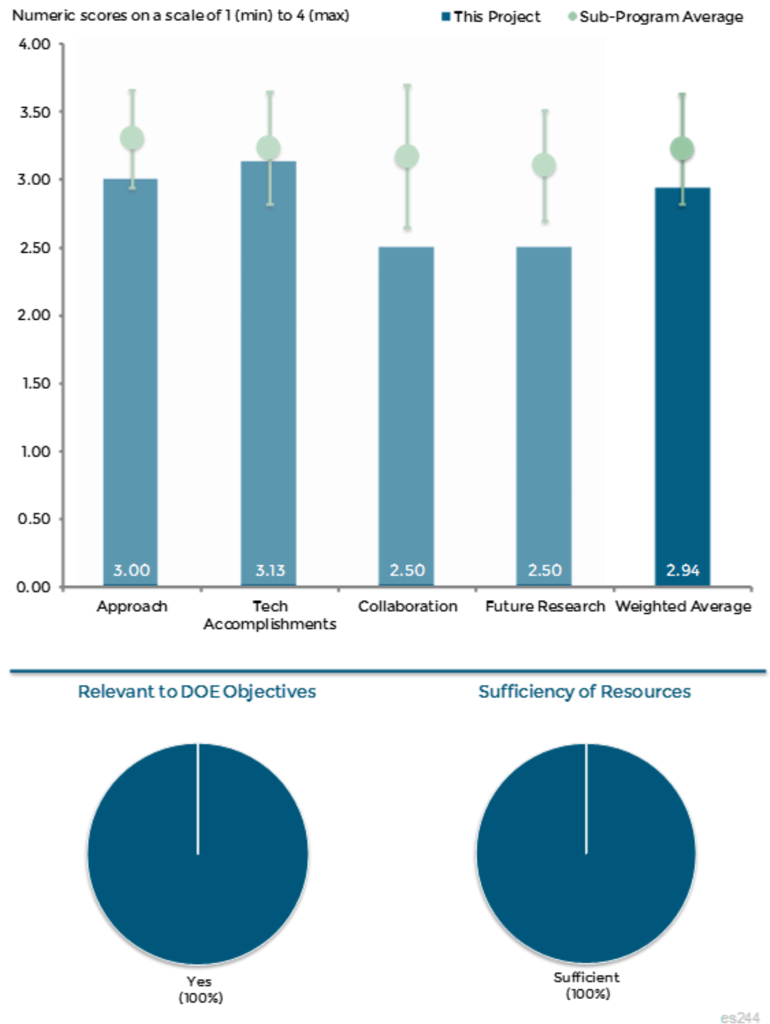


Figure 2-60 Low-Cost, High-Capacity Non-Intercalation Chemistry Automotive Cells: Alex Jacobs (Sila Nanotechnologies) - Electrochemical Energy Storage

Presenter

Alex Jacobs, Sila Nanotechnologies.

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer noted that the core-shell silicon-based anode verses core-shell metal fluoride (MFx) cathode may have long life.

Reviewer 2:

The reviewer commented that this research is based on a sound concept that uses core-shell technology with a well-designed protective shell. However, due to proprietary considerations, very little information is provided on the specific technical approach in regards to chemistry and material science, and therefore, it is difficult to assess the technical approach.

Reviewer 3:

The reviewer stated that due to the limited information in slides and presentation, it was hard to evaluate technical approach.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer explained that half-cell performance is good enough for further development, and that the cell level cycle life should be greater than 1,000 cycles.

Reviewer 2:

The reviewer commented that in the approach, rate capability also must be demonstrated.

Reviewer 3:
The reviewer stated that the results presented are promising, however, the electrode loading data is not provided.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer observed that project's collaboration partners are well established.

Reviewer 2:
The reviewer explained that collaboration partners would otherwise seem excellent, but the unknown automotive partner is not identified. It seems inappropriate to not identify a partner if they are generically highlighted.

Reviewer 3:
The reviewer stated that in addition to ARL and Georgia Institute of Technology, a cell developer must be included for further development.

Reviewer 4:
The reviewer remarked that it is not very clear in the project's collaboration of how the outcome from each institution is integrated.

Question 4: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer expressed that it is important to plan technology demonstration with a full cell with a relevant capacity of 5 Ah or more.

Reviewer 2:
The reviewer commented that it is not very clear how the cells will be fabricated and the objectives will be validated.

Reviewer 3:
The reviewer noted that no future work is provided.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer explained that the end goals of the project of 1,200 Wh/L and 580 Wh/kg are very impressive and should reduce the battery mass and volume significantly.

Reviewer 2:
The reviewer observed that the project supports increasing energy density for an automotive application.

Reviewer 3:
The reviewer stated that low-cost and high-capacity automotive cells are required to achieve the DOE plan.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that $1 million is sufficient.

Low-Cost, Structurally Advanced Novel Electrode and Cell Manufacturing: Taison Tan (24M Technologies) - es245

Presenter

Taison Tan, 24M Technologies.

Reviewer Sample Size

A total of three reviewers evaluated this project.

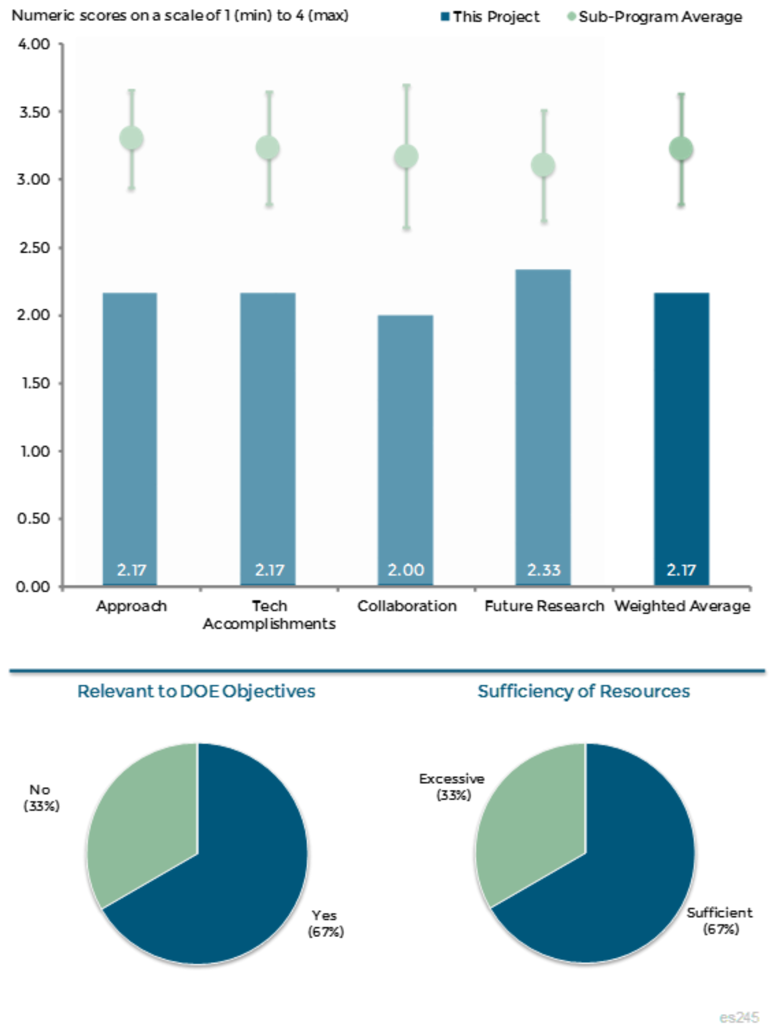


Figure 2-61 Low-Cost, Structurally Advanced Novel Electrode and Cell Manufacturing: Taison Tan (24M Technologies) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer said that using a new architecture to produce thicker electrodes for higher specific energy cell is a new approach.

Reviewer 2:

The reviewer commented that the project approach is unknown.

Reviewer 3:

The reviewer expressed that the project approach is very difficult to assess given the paucity of information.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer that the specific charge and discharge power looks good for a thick electrode.

Reviewer 2:

The reviewer stated that project team’s progress is unknown.

Reviewer 3:

The reviewer stated that there needs to be more information to assess the technical accomplishments. There is no cycling data, neither Wh/kg nor Wh/L.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that the project team’s collaboration with equipment producers is good enough.

Reviewer 2:

The reviewer observed that the project has no partners, although perhaps that is appropriate given where 24M is in the development cycle.

Question 4: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer explained that the development to increase the electrode thickness to meet high-specific energy goal is very important.

Reviewer 2:

The reviewer stated that the proposed future research is unknown.

Reviewer 3:

The reviewer remarked that the proposed future research has very few details, and cannot understand what issues the project team is having when trying to mitigate.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer noted that the high specific energy cells will improve the probability of success.

Reviewer 2:

The reviewer stated that the project relevance is unknown.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer explained that $2 million to prove the concept and cell development is sufficient.

Reviewer 2:

The reviewer observed that the project activity relative to resources is unknown.

Advanced Drying Process for Lower Manufacturing Cost of Electrodes: Iftikhar Ahmad (Lambda Technologies) - es246

Presenter

Iftikhar Ahmad, Lambda Technologies.

Reviewer Sample Size

A total of four reviewers evaluated this project.

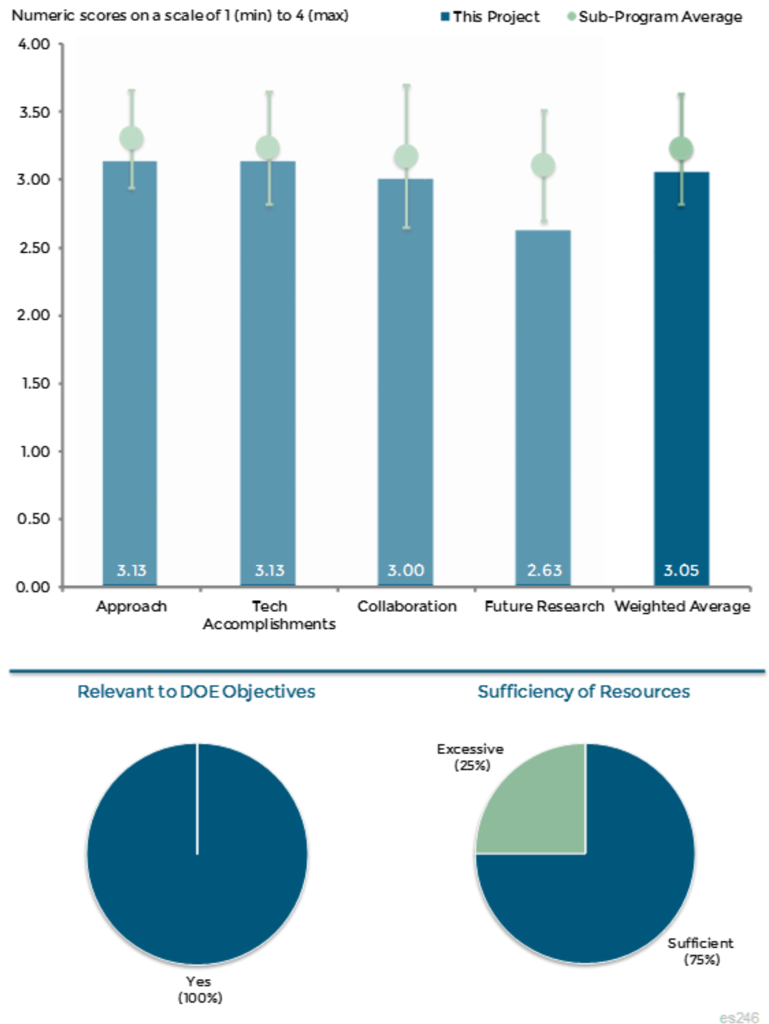


Figure 2-62 Advanced Drying Process for Lower Manufacturing Cost of Electrodes: Iftikhar Ahmad (Lambda Technologies) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commented that project's general approach seems excellent. Apparent oven design capabilities seem a little limited, and maybe, could have/could benefit from expertise or manpower of related normal oven equipment designers, but given the limits of the total budget situation which is understandable and the honest depiction of the actual current situation which is refreshing.

Reviewer 2:

The reviewer stated that the project team has sound approach and plan in demonstrating the technical feasibility of this technology.

Reviewer 3:

The reviewer noted that the approach is a drying process that uses microwave to reduce the dying time and the cost of drying.

Reviewer 4:

The reviewer remarked that the idea is quite straight forward, as many experimental studies on the effect of advanced drying process (ADP) on battery performance such as surface reaction and mechanical stability must be conducted. The cost analysis for drying process will also be needed in terms of energy and additional facility needed.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:
The reviewer said that the comparison of drying time between standard and ADP methods was done under only one loading for anode and cathode, and it is useful to demonstrate the effect of loading on the drying time so that the work can establish the loading window in which the proposed ADP will be preferred over the standard method. The reviewer asked how the performance of drying time varies with anode type, specifically when comparing graphite and silicon-based anodes.

Reviewer 2:
The reviewer noted that the electrode samples had 2,000 parts per million (ppm) solvents.

Reviewer 3:
The reviewer remarked that adhesion and binder distribution tests are not clear about how they were conducted. Optimizing the proposed approach may further improve the outcome further. The reviewer also remarked that scalability would be of interest for practical purpose. Additionally, applicability for other materials will be important.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer said that Navitas Systems seems like a good and very appropriate partner for this project.

Reviewer 2:
The reviewer stated that the project team's collaboration with Navitas Systems seems to be well established, and the actual collaborative work is planned for the remainder of the project.

Reviewer 3:
The reviewer noted that Navitas Systems will evaluate the electrodes.

Reviewer 4:
The reviewer remarked that the project team's collaboration is not clearly described. A more detailed electrochemical test may be expected from the battery company collaborator.

Question 4: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer noted that the continuation of collaboration with Navitas Systems will help.

Reviewer 2:
The reviewer stated that understanding final cell or electrode size limits, which is expected at end of project, would be useful.

Reviewer 3:
The reviewer commented that a safety test also must be conducted.

Reviewer 4:
The reviewer reported that a stated project goal is 30 to 50% cost savings, but the proposed work does not include a cost analysis. Cost comparison with conventional drying technology is essential in evaluating the

benefits of the ADP. The reviewer said that the potential safety issues related to the use of microwaves needs to be addressed.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer noted that if the project team is successful, the cost of cell manufacturing will go down.

Reviewer 2:

The reviewer stated that this project aims to reduce the battery cost.

Reviewer 3:

The reviewer explained that cost reduction of manufacturing is necessary for the achievement of DOE's objectives.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer expressed that the project seems worthy of additional resources, particularly if added expertise in normal Li-ion oven design is included.

Reviewer 2:

The reviewer commented that the detailed budget plan and its usage are not provided.

Reviewer 3:

The reviewer noted that $1 million to develop the drying process may be excessive.

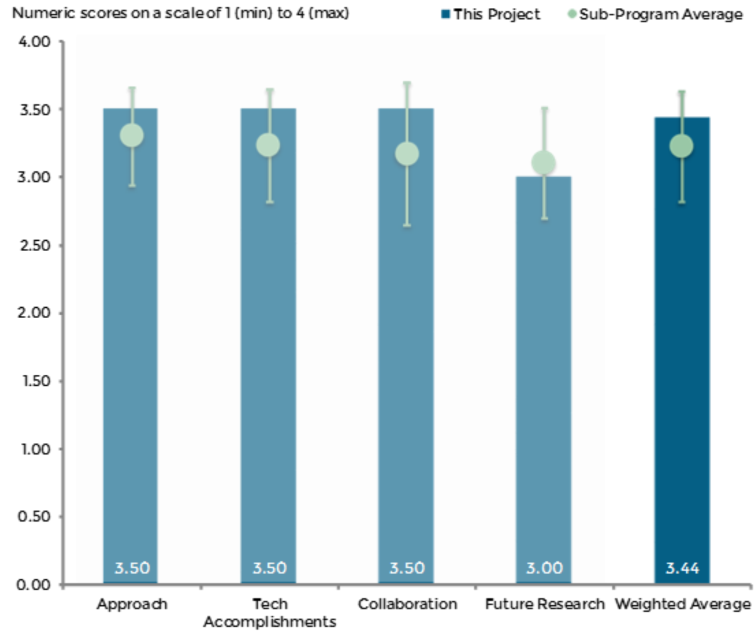
EV Battery Development: Herman Lopez (Envia Systems) - es247

Presenter

Herman Lopez, Envia Systems.

Reviewer Sample Size

A total of three reviewers evaluated this project.



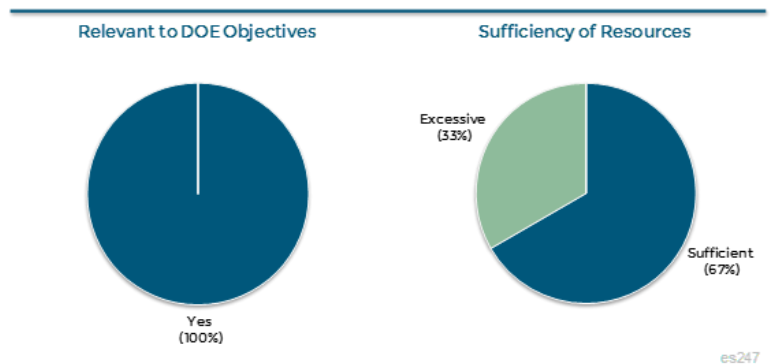


Figure 2-63 EV Battery Development: Herman Lopez (Envia Systems) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer explained that the approach adopted in this project is systematic and well planned, and according to the information provided, the project execution follows the planning. Capacities and capabilities of the partners appear to be appropriately chosen. The reviewer opined that the barriers described on the poster are not barriers, but goals. Nevertheless, the goals to be achieved are ambitious, which are achieving USABC cell targets including cell energy and power goals, calendar and cycle life goals, and cost.

Reviewer 2:

The reviewer stated that the project has a broad scope covering multiple areas requiring improved materials, but has done an outstanding job of organizing the many aspects of the project work and identifying the key barriers to be overcome.

Reviewer 3:

The reviewer explained that the approach for testing new materials and identifying the best performing materials is reasonable, and the flow chart is helpful. Although it is hard to know, however, the reviewer expressed a need to know if it is better first to optimize electrodes, and then look for electrolytes, for example, if another set of electrodes could be better performing if a different original electrolyte had been chosen. The roadmap presented could lead to a local maximum in performance, preventing the group from reaching the overall maximum.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer commented that the technical work done has been considerable and matches the work plan of carefully selecting candidate materials for the next stages of the project.

Reviewer 2:

The reviewer observed that despite the incipient nature of the project of 25% completion, good progress has been demonstrated. The project is coordinated well with well-defined contributions from each partner combined with independent testing from Idaho National Laboratory (INL). The reviewer added that while the cycle life goal is 1,000 cycles, data on capacity fade has not been demonstrated above 200 cycles.

Reviewer 3:

The reviewer expressed an interest in the Si alloy materials composition and was told it was proprietary. It is hard to evaluate the practicality of a material without knowing its composition. Same comment about Asahi Kasei Corporation. Knowing the materials composition would be helpful in an evaluation, at least knowing if it is a polymer or ceramic at minimum. The reviewer asked if reviewers are to assume that if the company is interested in testing the separators, that they are thus cost effective enough to be commercializable. The reviewer asked what happens if they are not scalable. The reviewer also expressed that an evaluation cannot be provided without being able to learn more about the materials, and the same applies with the electrolyte.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that the role of each partner is clear and the coordination of the execution of the work by the project leader appears good. Involvement and independent testing by INL is commended.

Reviewer 2:

The reviewer said that the project has many top industrial and national laboratory partners to provide expertise in the selected areas. The work done shows that these institutions have been well involved in the experimental work.

Reviewer 3:

The reviewer observed that there is a lot of coordination with companies, but it appears that no national laboratories or universities have been included. Some national laboratories were listed as part of the deliverables bullet, but without co-funding, the reviewer asked how they will guarantee their involvement.

Question 4: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer explained that the project is still at an early stage but the timely achievement of milestones is encouraging, where the future work seems to be planned appropriately. More detailed information on a risk assessment exercise for a project would be useful to evaluate this criterion better, for example, how does this project evaluate the risk of a partner not delivering a material and component and what mitigating actions and alternatives are taken in this case to reduce the negative impact on the project outcome.

Reviewer 2:

The reviewer commented that the ambitious scope of the project has multiple barriers, especially in the silicon anode area. As such, it would be advisable to include some focus on searching out and evaluating new materials and technologies from others, such as prelithiation technology and ceramic separators.

Reviewer 3:

The reviewer noted that not many details about the future research were provided.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that higher performance batteries are a necessity to facilitate the displacement of petroleum in automotive applications by providing e-mobility options with performances meeting the consumer's expectations. This project has the potential to contribute to improving performance characteristics of LIBs.

Reviewer 2:

The reviewer said that the project is directed at the next generation, low-cost Li-ion battery for vehicles and thus fits in with the DOE's objectives.

Reviewer 3:

The reviewer noted that project probably supports the DOE's goals assuming that the materials being tested are scalable and cost-effective.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer observed that the large number of partner institutions provide sufficient resources when combined with the resources at Envia Systems.

Reviewer 2:

The reviewer expressed that resources should not be directed to projects for which materials composition is not revealed, and to understand if other researchers are supposed to benefit when the results are proprietary materials. Only the companies benefit in this case.

Development of a PHEV Battery: John Busbee (Xerion Advanced Battery Corporation) - es248

Presenter

John Busbee, Xerion Advanced Battery Corporation.

Reviewer Sample Size

A total of three reviewers evaluated this project.

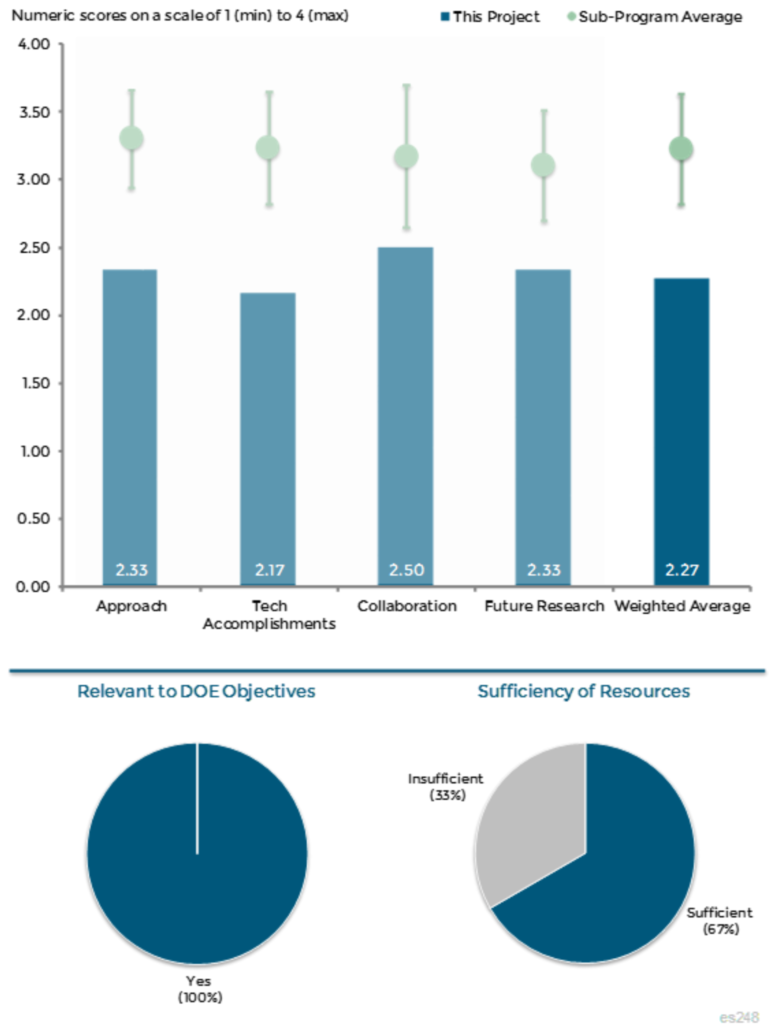


Figure 2-64 Development of a PHEV Battery: John Busbee (Xerion Advanced Battery Corporation) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer said that the project milestones appear to be on track, and the approach to compare the performance with commercial cells is commended as is the independent testing by ANL. The technical accomplishments are well documented and evidenced with data.

Reviewer 2:

The reviewer observed that no representative of Xerion Advanced Battery Corporation was at their poster for all or nearly all of the session, so it was not possible to ask questions to clarify aspects of the project. The manganese oxide spinels (LMO) cathode design and process appears to be very complex, for it is difficult to see how this could provide a low-cost LMO cathode with consistent quality. The reviewer went on to say that the pores are described as Nano-scale, but the SEM photos of the pores appear to be about 1 micron in size, not the 0.1 micron or less diameter of nano-scale. In the approach, there was no discussion of the percent porosity of the LMO cathode of this project as compared to the about 30% porosity of the calendared LMO cathodes now being used. The reviewer stated that a large focus of this project is on high-power rates, but this is only valid if the percent porosity of the LMO cathodes of this project is not well above the about 30%.

Reviewer 3:

The reviewer commented that while work is definitely an interesting technology, the reviewer would like to know how scalable the scope is, what the current cost is, and does the foam contains both the Li metal oxide and conductive carbon, or another composition. The reviewer also expressed to know how much sacrificial material is lost during the electrode fabrication process, mow much is this cost, if it is isolatable after removal, and if these cathodes have ever been tested in full cells. The reviewer noted that it would have been good to ask the PI these questions, but no one was at the poster during the poster session, and the reviewer checked multiple times.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer stated that in general, the technical accomplishments are well described. The specific energy claimed of 260 Wh/kg, is based on electrode weight; however, its specific energy relative to cell weight as per the USABC target cannot be evaluated.

Reviewer 2:

The reviewer asked why the LMO was selected over LCO in October 2014, and where the cycling data is showing that both materials were made and studied, or if only LMO was fabricated. The reviewer also asked on what scale the electrodes have been fabricated, and how many batteries have been fabricated and tested. The reviewer commented this product should be tested side-by-side with commercial cathodes, not pulling data from the literature and at different charging rates.

Reviewer 3:

The reviewer remarked that it is hard to evaluate the LMO cathodes of this project without having controls of conventional LMO cathodes, and without having some full cell data on at least the small cells. This project appears to be set up to compare the new LMO cathodes directly with typical LMO cathodes and to evaluate the new LMO cathodes, but it is not clear whether this was done, and what the anode, separator, and electrolyte each was used in the cells.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer observed that some partners and collaborations are mentioned. However, there is no information on what their contributions were and how they were coordinated.

Reviewer 2:

The reviewer explained that there is some project team collaboration with other institutions, but it is not clear what work that the team has done on the project.

Reviewer 3:

The reviewer commented that it is unclear what the coordinated activities with the institutions listed have been or will be. For example, the reviewer asked if the University of Illinois at Urbana-Champaign (UIUC) is getting funding to help with microstructural characterization, and what kind of testing has Intertek done or will do. The reviewer asked does the current award support these collaborators, but if not, how will collaborators make a significant contribution to the project.

Question 4: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer said that this project is approaching its conclusion in October 2015. Progress to date has been good, however, there are a number of outstanding barriers and challenges, and the time remaining also seems very short to achieve these objectives. As a general comment, the pdf of this poster was only available at the last minute. The poster was not hanging in the poster session, nor was anyone present. This has made the review of this work more difficult and the reviewer is not completely confident with some of the comments made. There are many things that the reviewer would have liked the PI to clarify during the poster session, but this was not possible.

Reviewer 2:

The reviewer noted that at this point in the project, the remaining barriers are not well characterized in terms of performance gaps and process feasibility, quality, and cost. Having the future research merely indicate building larger and more cells does not identify the barriers remaining and how they will be overcome.

Reviewer 3:

The reviewer observed that it appears that a lot remains to be done to determine if the material has a chance for commercialization. Specifics are not provided, and the PI was not available to answer questions about future tests, and therefore, a low score is being assigned due to lack of information.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer commented that the project is directed at one aspect of improving Li-ion batteries by making the next generation cathodes.

Reviewer 2:

The reviewer commented although this research is in much more basic stages than what would have been expected.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that the number of likely barriers to prove the feasibility of a new approach to LMO cathodes that involves many process steps and new current collection technology, combined with the relatively small budget of the project, appear to be insufficiently resourced.

Reviewer 2:

The reviewer noted that there is not enough information to judge if the resources are adequate or not.

Battery Development: Mohamed Alamgir (LG Chem Power, Inc.) - es249

Presenter

Mohamed Alamgir, LG Chem Power, Inc.

Reviewer Sample Size

A total of three reviewers evaluated this project.

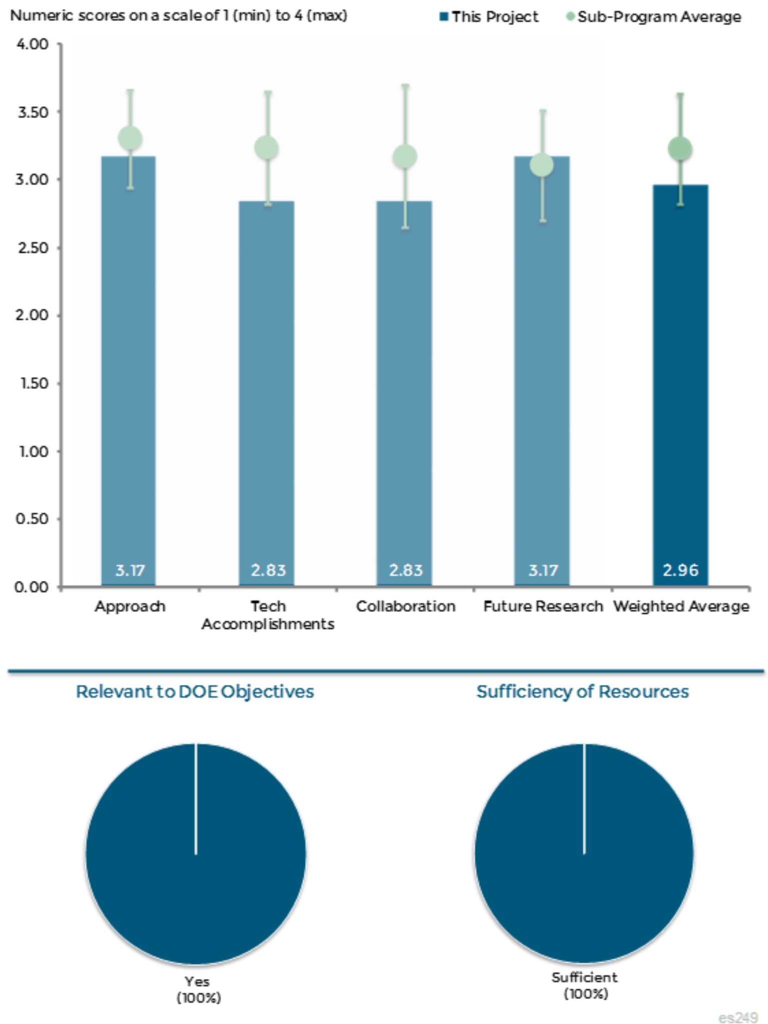


Figure 2-65 Battery Development: Mohamed Alamgir (LG Chem Power, Inc.) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that the project is taking a broad approach to overcoming the cold-cranking barrier starting with cathode materials and porosity and then evaluating the anode, electrolyte, and separator materials. The project has a good strategy to meet the low-cost pack barrier.

Reviewer 2:

The reviewer reported that the barriers being addressed in this project are clearly identified and the approach adopted is logical to try to overcome these barriers. Cost and performance at low-temperature are clearly critical barriers in this specific application, and addressing cost through simplifying the BMS is the correct approach. The reviewer went on to comment that the use of the term Polymer in the title of the project's poster of the 12V Start-Stop Li-Polymer Battery Pack is confusing, if not misleading, for a system that uses a non-aqueous electrolyte.

Reviewer 3:

The reviewer noted the bullet point lower cost close to the $220 target, and asked what does this mean, and how close is the project to the team’s actual goal. While the PIs are clearly doing work to improve performance, the approach is vaguely defined.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer commented that the project work on the cathodes was useful as the first step in achieving the cold-cranking performance. Some quick screening of candidates for the anode, electrolyte, and separator would be good to see if one or more of these materials has good potential for further optimization to overcome the low-temperature performance gap.

Reviewer 2:

The reviewer observed that this project only started at the end of last year, and it is difficult to judge the achievement of project goals as a progress relative to project planning and the milestones were not evident. On the other hand, the technical accomplishments were evidenced, albeit at a basic level.

Reviewer 3:

The reviewer expressed the need to know how many batteries were tested, how many batches of materials were made, and how varied the surface area and porosity was. The amount of effort put into the project is hard to quantify.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer reported that this project is a collaboration between two divisions of LG Chem that are supported by testing services of national laboratories. Being the case in this project, there is limited scope for the evaluation of the project team's collaboration and coordination with other institutions, and the collaboration with national laboratories was identified as part of the future work.

Reviewer 2:

The reviewer noted that the project does not include many collaborating institutions but, most of the work can be done well in-house.

Reviewer 3:

The reviewer observed that there appears to be no project team collaborations with other institutions, but the validation will be completed in the future.

Question 4: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer explained that the optimization of the key cell component performance criteria and simplification of the BMS design, are proposed for future work, and if successful, these will certainly contribute to achievement of the goals set by this project and by USABC.

Reviewer 2:

The reviewer noted that the general approaches for future work are broad and appear to cover the main areas for optimization and cost reduction.

Reviewer 3:

The reviewer expressed the need to have access to more specific plans in order to better evaluate future research.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer said that the adoption of Start-Stop technology will have a positive impact, albeit there is a limited impact on petroleum displacement in the automotive sector.

Reviewer 2:

The reviewer stated that the project is directed at the important 12 V Start-Stop Li-ion battery in the DOE objectives.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer reported that the project is adequately resourced at one of the top Li-ion battery company developers and manufacturers.

A Commercially Scalable Process for Silicon Anode Prelithiation: Ionel Stefan (Amprius) - es250

Presenter

Ionel Stefan, Amprius.

Reviewer Sample Size

A total of three reviewers evaluated this project.

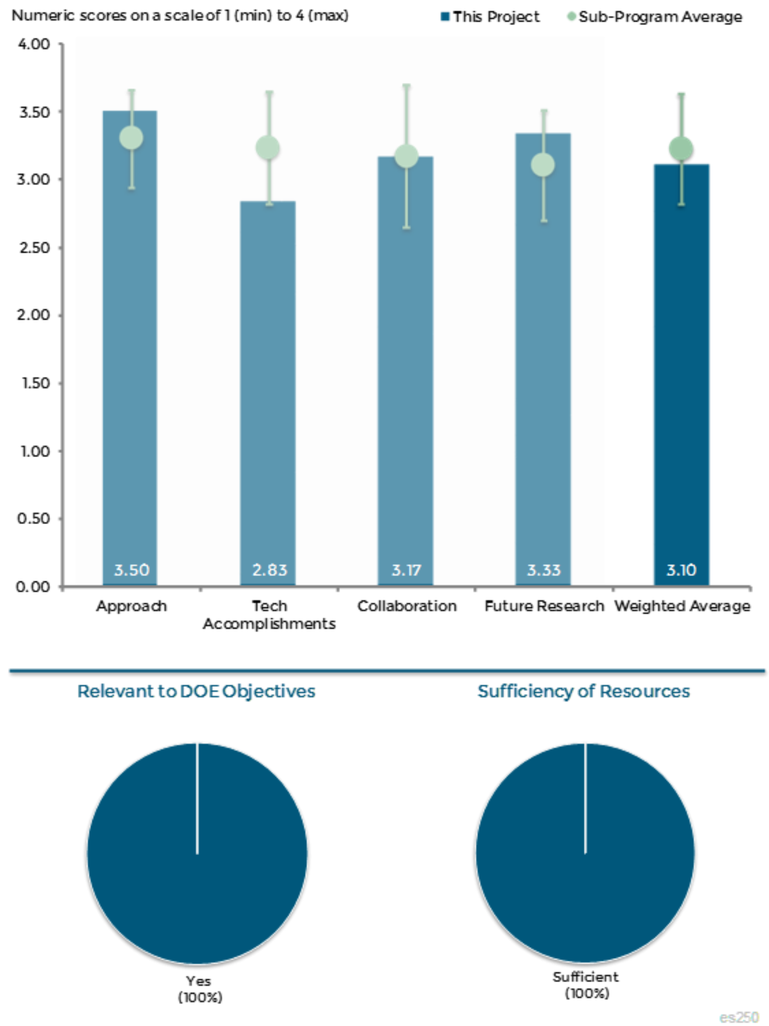


Figure 2-66 A Commercially Scalable Process for Silicon Anode Prelithiation: Ionel Stefan (Amprius) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commented that project motivation is clear, for the method of evaluating Li sources and lithiation techniques is well described and laid out, including performance characteristics and cost. The order of tasks is logical.

Reviewer 2:

The reviewer reported that the project has a single focus on developing a cost effective prelithiation process for the silicon nano-wire anode. Many approaches for prelithiation were evaluated which resulted in several potential candidates.

Reviewer 3:

The reviewer explained that increasing energy-density through pre-lithiation requires a cost-effective method for pre-lithiation of the Si-anode. Whether the pre-lithiation methods investigated in the project are suitable and effective for all Si-morphologies, needs to be demonstrated in order to judge its feasibility and integration with other's efforts. The reviewer added that the design and planning of the project activities and milestones seem appropriate, but one of the barriers identified, shelf-life, is not addressed in the material provided.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer commented that a large amount of work was done on evaluating many possible prelithiation approaches and selecting three of them as the most promising. There appear to be significant technical barriers yet to overcome, so it is not clear that any of these three approaches will show feasibility. The reviewer expressed that it would be good to continue to look for other strong candidates for prelithiation while working to optimize the three candidates identified in the first part of the project.

Reviewer 2:

The reviewer reported that the concept and potential of pre-lithiation has been demonstrated in this project, although the pre-lithiation techniques evaluated and preselected may depend on the anode morphology. The reviewer expressed the need to know how far the pre-lithiation effects would be applicable to other morphologies. Improvements in capacity retention through pre-lithiation are only effectively demonstrated for pre-lithiation levels greater than 400mAh/g, and it would have been interesting to see some independent testing of performance parameters, for example, reversible capacity and capacity retention.

Reviewer 3:

The reviewer said that words in the graph on Slide 15 provided in PeerNet are hard to read. The reviewer would have liked to see the initial results for cycle lifetime tests, even if only a few cycles.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer commented that while there are no partnerships involved in this testing, it is not thought to be necessary at this time. There are many tasks to be accomplished before it is necessary to involve someone for outside testing.

Reviewer 2:

The reviewer pointed out that the collaboration is not relevant in this project as there is only one partner. This project would definitely benefit from collaboration with other enterprises.

Reviewer 3:

The reviewer observed that this project has a relatively short length of one year and a relatively small budget. This is less oriented to extensive work with other institutions but the project states that it will be relying on vendors for support in doing the project work.

Question 4: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that proposed future work is well defined and logical, and thanked the PI for making an easy-to-follow presentation.

Reviewer 2:

The reviewer explained that planning is clear for the remaining months of this short project activity. As a single-participant project, an ex-ante risk-assessment exercise would have been useful to identify and mitigate the external risks needed to achieve the project goals, and in this case, to mitigate risks associated with the timely identification of a supplier of the bespoke pre-lithiation chamber.

Reviewer 3:

The reviewer reported that the project has a short length of only one year, so there may not be sufficient time to identify the cost-effective prelithiation process and demonstrate it on a pilot scale. It would be worthwhile to continue screening for any new prelithiation approaches in parallel in case while working to optimize the selected prelithiation candidates.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer noted that improving the cost of Si electrodes is a great area to explore for increasing energy density for PEV applications.

Reviewer 2:

The reviewer confirmed that the project addresses efforts to improve energy density and cycle life of energy storage systems.

Reviewer 3:

The reviewer explained that the commercial silicon anodes are the leading candidates for next-generation Li-ion batteries for the DOE's objectives. A cost effective prelithiation process is a common barrier for any of the silicon anode designs.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer observed that the project has sufficient resources as long as it follows its intent of engaging vendors where needed and to supplement its internal resources.

Reviewer 2:

The reviewer did not understand how the DOE's funding share is more than the contractor's share if Amprius is the project lead, or why no funds have been transferred during FY 2014.

12 V SS Battery Development: Michael Everett (Maxwell) - es251

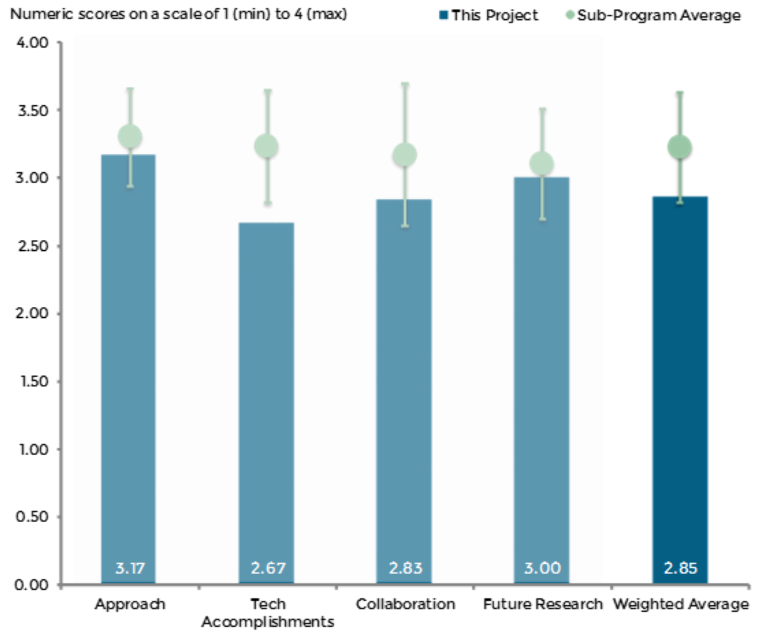
Presenter

Michael Everett, Maxwell.

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.



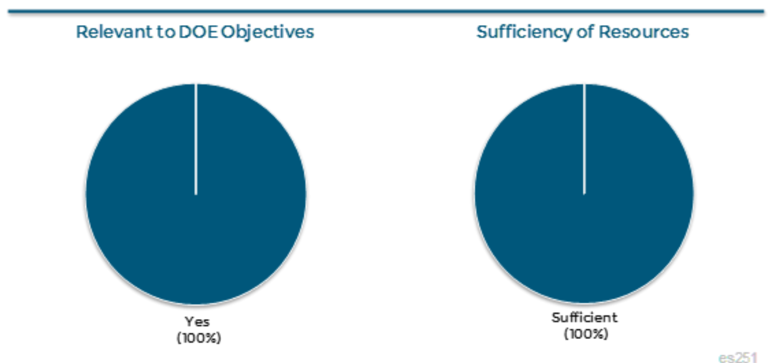


Figure 2-68 12 V SS Battery Development: Michael Everett (Maxwell) - Electrochemical Energy Storage

Reviewer 1:

The reviewer reported that the project approach is planned and scheduled well. In this project, critical barriers to developing a lead-free, more durable, and lighter 12 V alternative technology in a hybrid format are cost and complexity. The feasibility of the system being developed overcoming these barriers is questionable, particularly with respect to the energy management system and gas management. Integration of an ultra-capacitor for power in a 12 V system delivery is novel, especially at low-temperature.

Reviewer 2:

The reviewer commented that the approach is well-defined but requires performance based on the identification of additives that will lead to performance requirements based on their reactivity. The reviewer asked if there is a backup plan if such additives are not identified that both solve these problems and are cost effective.

Reviewer 3:

The reviewer stated that the project has a broad approach with a focus on overcoming the gas formation and mitigation barrier as a key enabling step.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer explained that the evaluation of a suitable electrolyte is an important aspect of this project together with management of gas, and that few results are presented to evidence the technical accomplishments claimed, e.g., results supporting the selection of electrolytes and results demonstrating the effectiveness of the gas suppression additive. The interchangeable use of the terms pouch, prismatic, and pouch prismatic to describe ultracapacitor cell format is both confusing and inconsistent.

Reviewer 2:

The reviewer reported that a considerable amount of work was done on evaluating electrolytes with acceptable gas formation with two candidates identified for further work. It would be advisable to continue screening for better electrolytes and to evaluate separators and other components that might lower the gas formation at high temperatures. The reviewer added that depending on a gas getter of some type to mitigate, the gas level may not be an approach that provides consistent quality.

Reviewer 3:

The reviewer explained that it was stated that two promising acetonitrile-based electrolyte formulations were identified. The reviewer asked what made them better than the others and what components were unique, what electrolytes are being tested in this project that are different from what others have evaluated, or if the same, what the motivation is for retesting them. The electrolyte screening work would be of interest to others in the field. The reviewer also expressed an interest to understand if there any plans to disseminate knowledge through peer-reviewed literature.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted that project team's collaboration with two national laboratories is an integral part of the project.

Reviewer 2:

The reviewer observed that ANL and NREL are listed as collaborators but it is not clear if and in how far the collaboration is realized.

Reviewer 3:

The reviewer said that it is unclear what work was done by Maxwell verses the USABC within the proposal, and understands that NREL does thermal modeling. The reviewer expressed the need to know what kind of thermal testing has and will NREL do that is specific to this battery system, and if the work is ongoing or to be in the future.

Question 4: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer said that the degree to which the cost and energy management system barriers are overcome are addressed in the future work of this project. Demonstration of the proof of concept system is an important future milestone and independent testing by the national laboratories will provide important proof.

Reviewer 2:

The reviewer stated that the ultracapacitor component of the project needs significant design improvements, especially for acceptable gas formation levels. Broader efforts are needed to get this design ready on schedule for building into the battery system and evaluating it for performance against the project targets.

Reviewer 3:

The reviewer explained that specifics for future work are not enough to evaluate its merit. For example, in one case, 20-plus carbonate-based formulations have been tested with no promising candidates. The reviewer asked what will be done in the next round of testing that is different from what has already been tested that will increase the likelihood of success.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer stated that Start-Stop technology offers some fuel economy gains which, to some degree, contributes to objectives towards petroleum displacement.

Reviewer 2:
The reviewer noted that the 12V Start-Stop lithium-ion battery and ultracapacitor combination is part of the DOE's objectives for vehicles.

Reviewer 3:
The reviewer said that the improvements in energy storage systems could allow for decreased utilization of coal burning power plants or of renewable energy sources.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer stated that the project is being done at the leading ultracapacitor company in the United States with support by two national laboratories for the testing.

Reviewer 2:
The reviewer remarked that without access to the budget or description of facilities, it is not clear if the resources available are appropriate or not.

New High-Energy Electrochemical Couple for Automotive Application: Xiao-Qing Yang (Brookhaven National Laboratory) - es255

Presenter

Xiao-Qing Yang, Brookhaven National Laboratory.

Reviewer Sample Size

A total of four reviewers evaluated this project.

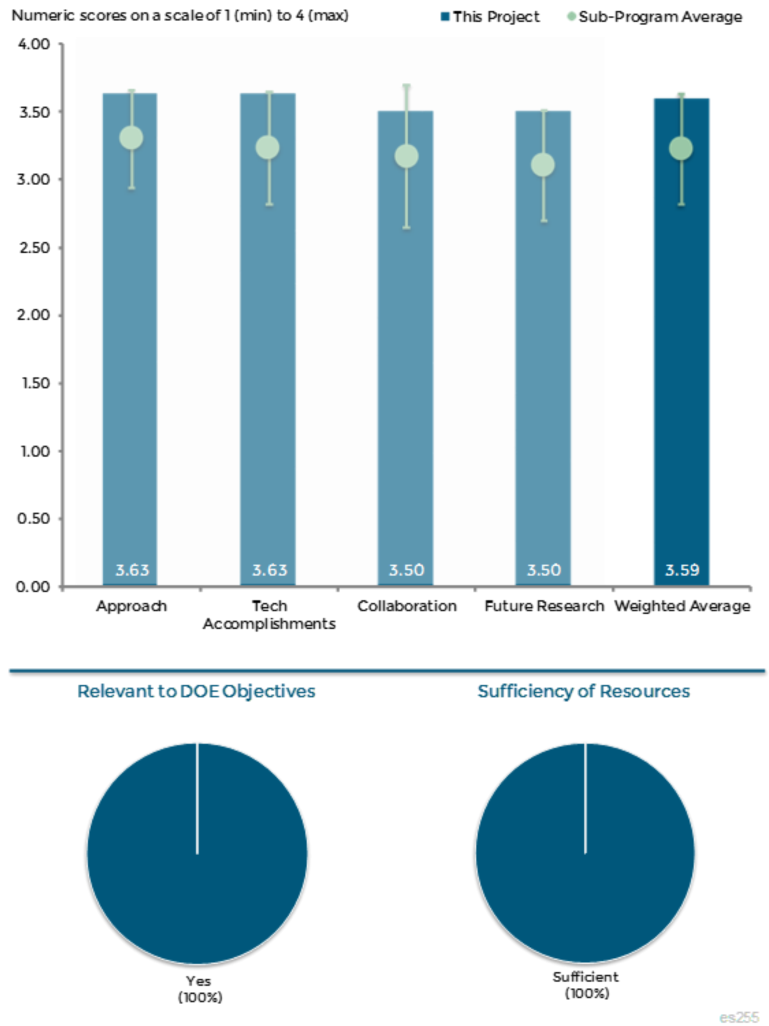


Figure 2-69 New High-Energy Electrochemical Couple for Automotive Application: Xiao-Qing Yang (Brookhaven National Laboratory) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that the in-situ time-resolved X-ray diffraction (TR-XRD) coupled with mass spectroscopy (MS) was interesting and the data collected was very compelling. It shows that the disordered spinel and final rock-salt structure are formed as the charged cathode powder is subject to higher temperatures, and that the stability-gain reported for the gradient material is very clear.

Reviewer 2:

The reviewer expressed that the principals laid out in a very well organized approach to developing techniques that would allow a more fundamental understanding of key active material characterization. The goals were clear and the follow through stayed on task.

Reviewer 3:

The reviewer explained that the work aims to analyze and compare concentration gradient (CG) NMC622 and NMC622 without CG bulk, and that the thermal stability of this material is a critical point as it is one of the major drawbacks of the material, so the work is of major importance. TR-XRD and soft X-ray absorption spectroscopy (SXAS) are used as methods, and additionally, transmission X-ray microscopy (TXM) is utilized to visualize the elemental distribution of Ni, Mn and cobalt (Co) within the CG NMC622. The reviewer added that this work is thoroughly performed with emphasis on detail and gives significant input on the thermal stability of NMC622 materials.

Reviewer 4:

The reviewer stated that TR-XRD may provide less detailed structural information compared to the conventional approach. For SXAS, the ability to decipher both the surface and bulk structure is very useful and powerful.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer stated that the demonstration of an increased thermal stability for the gradient cathode powder was a good accomplishment. The TR-XRD/MS plots and the contour plot were very easy to follow, and the effect of temperature was clearly displayed.

Reviewer 2:

The reviewer reported that the progress of the first year is impressive and depicts also the good collaboration in this project, and the chosen techniques and the approach are well suited for the tasks and ensure the progress. Detailed and elaborated results are shown correlating the thermal stability of bulk NMC622 and CG NMC622 to the phase-transformation of the material. The reviewer also said that the results are important and can provide significant information towards the improvement of these materials, but more work is needed in order to correlate the material properties to electro-chemical performance and the lifetime. It is appreciated that this is already addressed in the proposed future research.

Reviewer 3:

The reviewer noted that the project team has good progress on both the thermal stability studies and the metal mapping work.

Reviewer 4:

The reviewer noted that the project team well demonstrated its applicability and unique capability with CG materials, but it is not very clear about the need of TXM.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer observed that the project team has clearly shown that it has good interaction with other institutions.

Reviewer 2:

The reviewer said that the project team’s collaboration combines several institutes and groups, and is well coordinated based on the strengths and capabilities of each partner.

Reviewer 3:

The reviewer noted that the project team’s collaboration is well described.

Reviewer 4:

The reviewer stated that project team’s collaborations appeared to be with very high quality partners, but a slightly more detailed description of who was doing what would be appreciated.

Question 4: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer explained that the future work is well coordinated and balanced. The reviewer commented the mentioned expansion of the collaboration should be described in some more detail for which partners and/or which tasks. It is recommended to focus on the correlation of the material properties to electrochemical performance and derive design guidelines for future concentration gradient materials.

Reviewer 2:

The reviewer noted that the project team's collaboration with U.S. academic research institutions will be important for quick dissemination of the advanced technologies.

Reviewer 3:

The reviewer believed that the tools have shown good usefulness in the areas of interest, and hoped these tools can be used on other active material systems in the future.

Reviewer 4:

The reviewer commented that as mentioned by the authors, the thermal abuse tolerance will be extended using their in situ method, and that the addition of surface and bulk sensitivity analysis will be very useful. The project team may end up providing some light into the mechanism of degradation and potential mitigation strategies.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer remarked that yes, the project is very relevant to the objective of petroleum displacement.

Reviewer 2:

The reviewer stated that the diagnostics study for safety and calendar and cycle life is essential to improve battery performance, which is significant for the achievement of DOE's objectives.

Reviewer 3:

The reviewer said that important information is provided on the thermal stability of NMC622 materials, with and without CG.

Reviewer 4:

The reviewer expressed that it is welcoming to see some solid fundamental material analysis aimed at key attributes affecting material behavior.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that project's resources are adequate and well allocated to achieve the goals of the project.

Reviewer 2:

The reviewer observed that the project's resources seems sufficient, however, if the authors tried to extended their study into many more cathode powders, the resources may not be sufficient.

Reviewer 3:

The reviewer commented that a detailed budget is not provided.

3M IC3P - Research Focus: Jagat Singh (3M) - es256

Presenter

Kevin Eberman, 3M.

Reviewer Sample Size

A total of four reviewers evaluated this project.

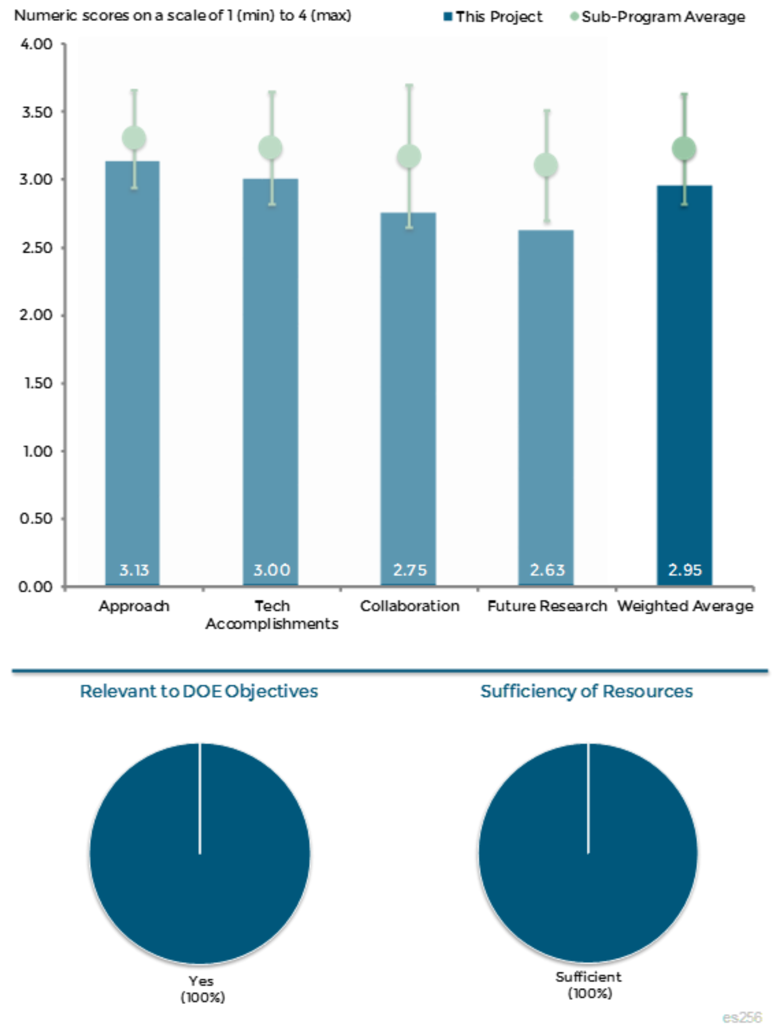


Figure 2-70 3M IC3P - Research Focus: Jagat Singh (3M) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer explained that the investigation phase of the research provides a well-executed study of the target performance parameter and ultimately provides some real insight into potential causes of issues within the Si anode system.

Reviewer 2:

The reviewer stated that the author seems much focused on the Si alloy challenges, and FEC is playing an important positive role. However, gassing seems to be one the main problems to focus on, and the authors are working on it.

Reviewer 3:

The reviewer said that the PI is not very clear about the strategy to solve the problems. The impact of additive materials on cathode side must be considered, for it is well known that FEC has impact on cathode.

Reviewer 4:

The reviewer commented that no explanation of the scientific approach is given in the presentation, and obviously it is focusing on the failure mechanisms during cycling of the Si-alloy. Effects of electrolyte mixture, cathode material and, for one example, the associated volume exchange are being investigated. The reviewer added that this work seems more like engineering work of test and see what happens, than scientific work to find causes scientifically and solve the problems, and is in particular disappointing as the project es255 was understood as deep dive linked to project es210.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer reported that the authors made real progress on the sudden fade mechanism due to the silicon anode, but at some point, the authors should mention what is meant by the term improve microstructure. Electrolyte with VC-ethylene acrylic (EA) solvent seems to greatly help. Similarly, the NMC cathode seems to be playing a role in mitigating the sudden fade. The reviewer commented that at some point, the authors should provide some information about the mechanism behind that positive effect.

Reviewer 2:

The reviewer explained that the progress in addressing performance issues provides some interesting avenues for exploration, and the development for these approaches is less compelling than the initial evaluation, with some of the outcomes ranging from interesting to perplexing. The observation of FEC gassing seems to be developing as a common issue in the Si anode field and needs to be driven to ground. The reviewer added that the observation of performance differences based on cathode choice alone, are very perplexing, and while it is appreciated that they are included, it is somewhat perplexing on the potential mechanism.

Reviewer 3:

The reviewer observed that some changes, for example, electrolyte or matching cathode, showed the improvement of lifetime. Such results can be important for further development of Si-based materials to achieve longer cycle life. However, the reviewer commented that explanations are missing why such changes resulted in the improvement. In order to make further simple and logical investigations, the effect of such electrolyte or cathode change on the Si-alloy needs to be better understood. The reviewer added that in particular, the improvements shown are small and the present results are far away from the targets for automotive applications.

Reviewer 4:

The reviewer commented that all the project team's results look ad-hoc based on test.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that 3M Company is collaborating strongly with other institutions such as General Motors Company, LBNL, ARL, and Umicore.

Reviewer 2:

The reviewer remarked that there is no collaboration listed, but without details, the reviewer would not consider this to be a negative. As mentioned, the work appears to be high quality.

Reviewer 3:

The reviewer noted that from the presentation, there was no cooperation apparent.

Reviewer 4:

The reviewer commented that there was no clear description for collaboration.

Question 4: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer observed that in the area of future work, the project team has done a good job. Further studies related to the effect observed on the sudden fade by the different cathode powders should be pursued.

Reviewer 2:

The reviewer remarked that future work is not referenced in the enclosed document. It is perhaps somewhere else where this reviewer does not have access.

Reviewer 3:

The reviewer noted that proposed future work was not described.

Reviewer 4:

The reviewer commented no future plan.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer remarked that yes, understanding and improvement of life time of Si based material is important to achieve the DOE's objectives, as Si based material have higher capacity than current typical graphite which can lead to the realization of the higher energy density Li-ion battery cells.

Reviewer 2:

The reviewer said that yes, the project is very relevant to the objective of petroleum displacement. The development of high-energy Si alloy anodes will result in higher energy batteries.

Reviewer 3:

The reviewer stated that this work provides at least some insight into mechanistic issues associated with Si anode performance. Much more work is needed, but progress will be very sporadic without more work like this being developed.

Reviewer 4:

The reviewer noted that Si alloy is one of the important materials for achieving the DOE's objectives, but the cause of sudden fade must be resolved.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented that the project's resources seems to be sufficient.

Reviewer 2:

The reviewer stated that project's resources were not given in the presentation.

Reviewer 3:

The reviewer noted that project team provided no detailed budget information.

Ion-Exchanged Derived Cathodes (IE-LL_NCM) for High-Energy Density Lithium-Ion Batteries: Christopher Johnson (Argonne National Laboratory) - es257

Presenter

Christopher Johnson, Argonne National Laboratory.

Reviewer Sample Size

A total of four reviewers evaluated this project.

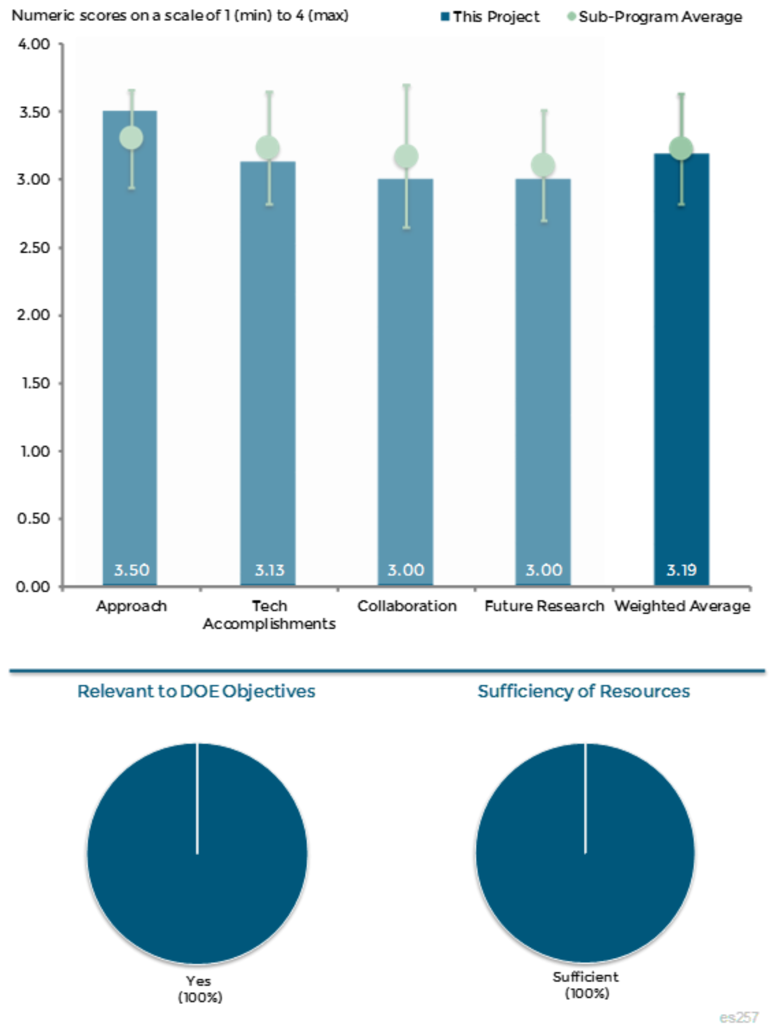


Figure 2-71 Ion-Exchanged Derived Cathodes (IE-LL_NCM) for High-Energy Density Lithium-Ion Batteries: Christopher Johnson (Argonne National Laboratory) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer said it is a very interesting approach that tries to stabilize the LMR-NMC cathode through new synthetic routes. The stacking faults approach of ion exchanged-layered layered-nickel cobalt manganese (IE-LL-NCM) followed by the authors seems to be a reasonable good alternative and the team has done a lot of work in that area; the reviewer remarked very focused.

Reviewer 2:

The reviewer said that according to the concept of project es213, this work shows two deep dives by ANL and LBNL into the two approaches to improve the capacity of the cathode material IE-HE-NMC and or modified NMC to allow for higher voltages. The scientific approach is well chosen and the techniques well suited to reveal substantial understanding of fundamental processes.

Reviewer 3:

The reviewer commented that the interest in attempting a new synthesis process as a method to modify the behavior of the Li-Rich active material system, is a worthy goal. It is not completely clear that the structural areas that can conceivably be modified by the proposed process line-up with a potential performance improvement, but making the attempt is probably reasonable.

Reviewer 4:

The reviewer stated that rate-capability also must be considered. Surface coating alone cannot solve the high-power properties.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer explained that the project team has made significant progress, and in particular, the results of LBNL are impressive. For the IE-HE-NMC, the progress in the synthesis of the material is also very good. But the reviewer recommended that the team think about additional analytical techniques beyond XRD, to further strengthen the understanding of the synthesis parameters, and to link it to the material characteristics and finally electrochemical and lifetime results.

Reviewer 2:

The reviewer explained that it will be interesting to know how much cathode material the authors can produce in one batch, for the researchers already mentioned that the scale-up is in the horizon. At some point, it will be of great interest to know the reproducibility of the ion exchange process in more detail. The reviewer added that the authors mentioned that there is some composition variance in the process.

Reviewer 3:

The reviewer noted that the demonstrated cycle-number is too small to be competitive to other materials.

Reviewer 4:

The reviewer stated that the signals from the material produced by the process do not indicate a high-probability of success in addressing the target performance characteristics.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that the project team's collaboration seems to be very good with Farasis Energy, which is a battery company, and that is very good.

Reviewer 2:

The reviewer said that the research seems to be well connected with the other project partners. Testing this material in commercial grade cells from Farasis Energy might unveil its full potential.

Reviewer 3:

The reviewer commented that there is very little project team collaboration at this stage, which is perhaps reasonable.

Reviewer 4:

The reviewer noted that the project team's collaboration is not clear.

Question 4: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that it seems that further exploration on the synthetic routes is a good alternative. Further characterization of the powders should be done, and additional insight into how scalable are these processes, should be considered too.

Reviewer 2:

The reviewer explained that the proposed future research is justified and continues to follow the route already taken. Input by the project partners can further elaborate the work and it will be interesting how the lower-voltage fade influences the material performance in larger cell formats.

Reviewer 3:

The reviewer commented that it is not clear that the current results suggest a strong case for further experimentation. As a further note, it would be important to know that if the process were capable of producing the intended structural and therefore performance characteristics. The reviewer asked does it have feasibility as a commercial process.

Reviewer 4:

The reviewer noted that the project team has no future work focused on rate-capability.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer said that yes, the project work is very relevant to the objective of petroleum displacement. How to mitigate the voltage-fade issue for the LMR-NMC layered compounds is a step in the right direction.

Reviewer 2:

The reviewer stated that high-capacity cathode material is an important component to DOE's development path.

Reviewer 3:

The reviewer commented that the project work is directly directed towards achieving battery energy density targets for xEVs.

Reviewer 4:

The reviewer noted that that the new cathode materials are necessary to improve the energy density of Li-ion cells.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that that the project is almost complete at this time and that the resources were good.

Reviewer 2:

The reviewer said that the project's dedicated resources are sufficient.

Reviewer 3:

The reviewer noted that the project team provided no detailed information about budget.

Envia IC3P - Research Focus: Robert Kostecki (Lawrence Berkeley National Laboratory) - es258

Presenter

Robert Kostecki, Lawrence Berkeley National Laboratory.

Reviewer Sample Size

A total of four reviewers evaluated this project.

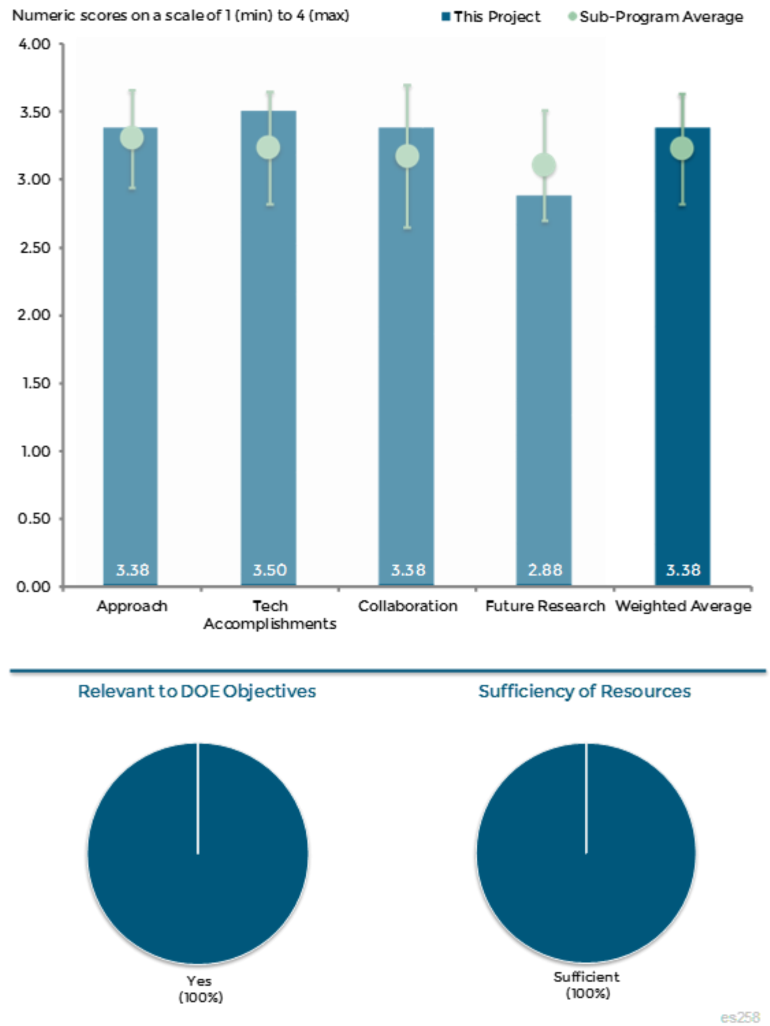


Figure 2-72 Envia IC3P - Research Focus: Robert Kostecki (Lawrence Berkeley National Laboratory) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that the research is well focused, and that the analytical information obtained with in-situ Raman seems very valuable and is giving important information at the surface and electrolyte interphase. The data collected with the HCMR baseline materials gave very useful hints to Envia Systems.

Reviewer 2:

The reviewer expressed that there is an appreciation for the effort to investigate mechanistic causes for materials performance. Applying multiple analytical techniques and attempting to reconcile their collective results is also appreciated.

Reviewer 3:

The reviewer explained that the project is well-designed to investigate the fundamental problem of the direct current resistance (DCR) rise in HCMR cathodes. The multi-scale approach and the combination of spectroscopic techniques, calculations, and electrochemical investigations is well thought through and may provide new insight into the structural problems of the material.

Reviewer 4:

The reviewer stated that the approach is not very clear about doping study for the goal of the project is to understand DCR increase.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer commented that overall, the project team has shown great progress. The in-situ Raman data was nicely utilized to confirm the formation of spinel-like structure after cycling.

Reviewer 2:

The reviewer stated that the development of a preliminary model for resistance increase is a positive step in the understanding of performance related to the HCMR material.

Reviewer 3:

The reviewer explained that the outcome of the project is good and the combination of the different techniques is very useful. Considering the dynamic changes on the surface of the electrode, it might be very interesting to also investigate the electrolyte at different potentials and see if the FTIR observed changes correspond to chemical changes in the electrolyte at these potentials. The reviewer added that the calculations showing the effect of doping on the Mn migration are interesting and opens new possibilities for material design.

Reviewer 4:

The reviewer commented that it is not clear about the explanation on higher DCR change at cycle 5 than cycle 100, for correlation between DCR and Li+ diffusivity is not strong against the claim in the summary. There are significant DCR changes within a single discharge as well as prolonged cycles, however, there is no change of Li+ diffusivity with prolonged cycling.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that the project team's collaboration between the different institutions has been very strong. General Motors, ORNL, and Envia Systems were involved and showed good coordination.

Reviewer 2:

The reviewer noted that a strong, diversified team seems to have produced good integrated results.

Reviewer 3:

The reviewer remarked that the project team's collaboration between the different groups involved is obvious, and that the work is well coordinated.

Reviewer 4:

The reviewer noted that the project has no detailed description or activity about collaboration.

Question 4: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer explained that the authors have done very comprehensive analytical work. After down-selecting the best composition, the team will be able to use the very promising diagnostic method described in the work, to move the project forward.

Reviewer 2:

The reviewer stated that the future research is not outlined in the presentation, and expressed an apology if there is a separate section which was missed.

Reviewer 3:

The reviewer reported that the presentation did not contain information on proposed future research, and that in the ranking, it was assumed that the groups continue the present approach. It is recommended to further link the results of the different techniques, and to even enhance the identification of the fundamental mechanisms.

Reviewer 4:

The reviewer commented that no specific future plan is given.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that the specific outcome of mechanistic understanding of this material is important for future research direction, as is the technique development can be applied to other materials.

Reviewer 2:

The reviewer said that yes, the project is very much aligned with petroleum replacement. The use of high-capacity cathode powder is badly needed in this area.

Reviewer 3:

The reviewer remarked that yes, the topic addresses one of the main risk items for layered-layered materials which is the low-power capability, and therefore, low-usable energy.

Reviewer 4:

The reviewer commented that understanding the DCR rise in high-energy density materials is essential for developing high-energy density Li-ion batteries.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer observed that the project's resources seems to be adequate. The project is finishing this year and the amount of data produced indicates that the resources have been well utilized.

Reviewer 2:

The reviewer noted that the project's resources were not given.

Reviewer 3:

The reviewer commented that no detailed information about budget is provided.

Prospects and Challenges of Nickel-Rich Layered Oxide Cathodes: Arumugam Manthiram (University of Texas at Austin) - es259

Presenter

Arumugam Manthiram, University of Texas at Austin.

Reviewer Sample Size

A total of four reviewers evaluated this project.

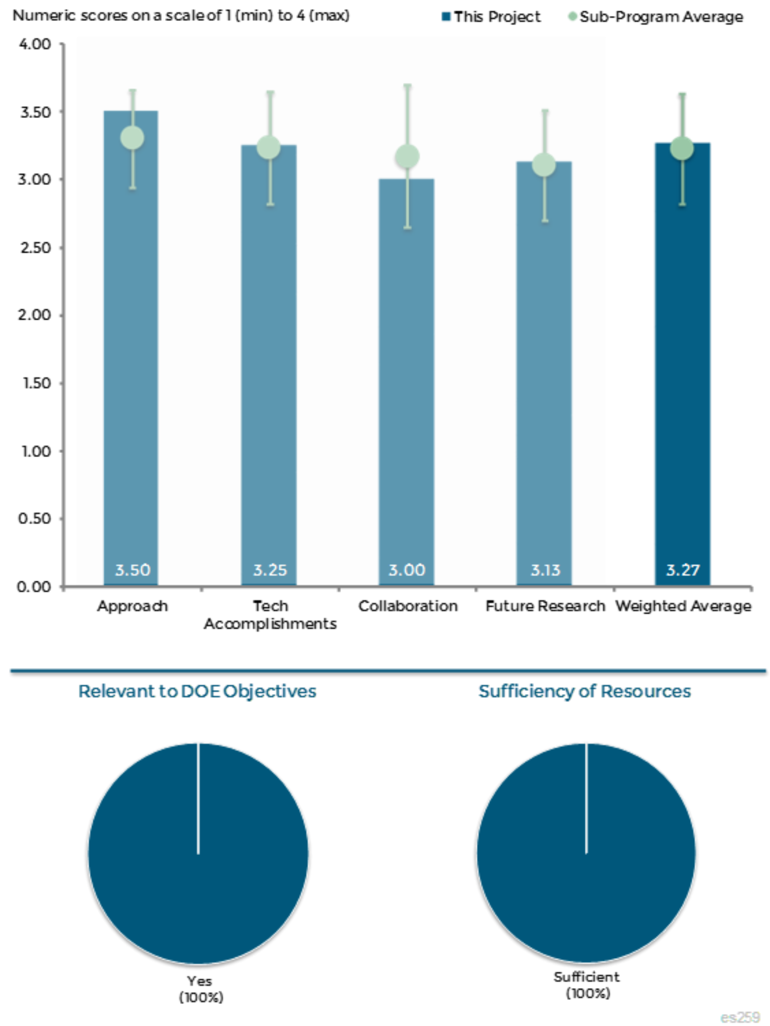


Figure 2-73 Prospects and Challenges of Nickel-Rich Layered Oxide Cathodes: Arumugam Manthiram (University of Texas at Austin) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer reported that the project work is focusing on synthesizing Ni-rich layered cathodes with a target of 220 mAh/g capacity, and is one of the most promising candidates to reach the DOE capacity targets. This approach of the work is very good starting with the synthesis and accordingly, process parameters. The reviewer added that the work thoroughly analyses the subsequent influence on particle size, morphology, properties, and electro-chemical performance, which is also very good.

Reviewer 2:

The reviewer said that the approach is good for it includes a comprehensive analysis of various parameters which affect the performance of the nickel-rich materials.

Reviewer 3:

The reviewer stated that the approach is effective in overcoming most barriers, for Ni-rich and gradient cathode powders are not easy to produce. At some point, a scale-up discussion should be introduced.

Reviewer 4:

The reviewer commented that this material is not gradient material and it may still have a problem related to mismatch between components.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:
The reviewer stated that the data and techniques associated with the characterization effort seem to be useful analytical techniques and results.

Reviewer 2:
The reviewer reported that substantial progress was shown for number of variants were synthesized and evaluated, and the fundamental understanding of the investigated sensitivities was increased. Even though improvements have been shown, it is still open how the targets can be reached. Moreover, the influence of the electrolyte on the performance of the cell was not discussed. The reviewer recommended that the team analyze the present results with the focus on a strategy to derive a design directive for the next material generation that can meet the target.

Reviewer 3:
The reviewer explained that it is clear that the constant concentration gradient is produced using a continuously stirred tank reactor, but it is not very clear how the authors can produce the concentration gradient powder. It seems that in that case, the project team will have to use a batch process.

Reviewer 4:
The reviewer commented that the project team needs to explain the observed phenomena in order to improve the performance. The relation between the particle size and impedance change is not clear and the demonstrated cycling life is not impressive.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer stated that it seems that the author is coordinating discussion with other groups.

Reviewer 2:
The reviewer observed that most of the collaborations seem to involve monthly project discussion, but is not quite sure what this means or what it accomplishes.

Reviewer 3:
The reviewer noted that the project team’s collaboration is well established.

Reviewer 4:
The reviewer remarked that the project work is done within a strong collaboration of partners. It would have been helpful to show in this presentation the interfaces to the partners, in particular, those who influence this work, for example, the influence of electrolytes as provided by ANL.

Question 4: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer reported that remaining project challenges are clearly recognized and the future work addresses these challenges. As the remaining time is quite short, it might be necessary to focus on the most promising action items.

Reviewer 2:
The reviewer said that the project's future work is effective; however, more examples of gradient powders are needed. Reproducibility of the results should be mentioned.

Reviewer 3:
The reviewer stated that the project team's goals are reasonable, of course, and well known. However, whether the effort can actually enable improvement toward these goals is yet to be determined.

Reviewer 4:
The reviewer commented that the project team needs to first understand the stabilization mechanism of the target materials. Then, the team needs to evaluate the long-term cycle performance.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer stated that developing a fundamental understanding of the factor that control the battery performance of high-energy density materials is urgently needed to achieve the DOE objectives.

Reviewer 2:
The reviewer explained that the project is very relevant to the DOE objectives, as a cathode with increased capacity is necessary in order to achieve the targets for future automotive applications.

Reviewer 3:
The reviewer said that yes, the project work is very relevant for the production of high-energy batteries.

Reviewer 4:
The reviewer stated that the high-energy cathode materials are an important component of advanced cell concepts.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer stated that the project's resources are sufficient for the amount of powder and different powders produced.

Reviewer 2:
The reviewer stated the resource amount and allocation are sufficient in order to achieve the targets of the project.

Reviewer 3:
The reviewer noted that detailed information about budget is not provided.

Materials Development for High-energy High Power Battery Exceeding PHEV-40 Requirements: Jane Rempel (TIAX) - es260

Presenter

Jane Rempel, TIAX.

Reviewer Sample Size

A total of four reviewers evaluated this project.

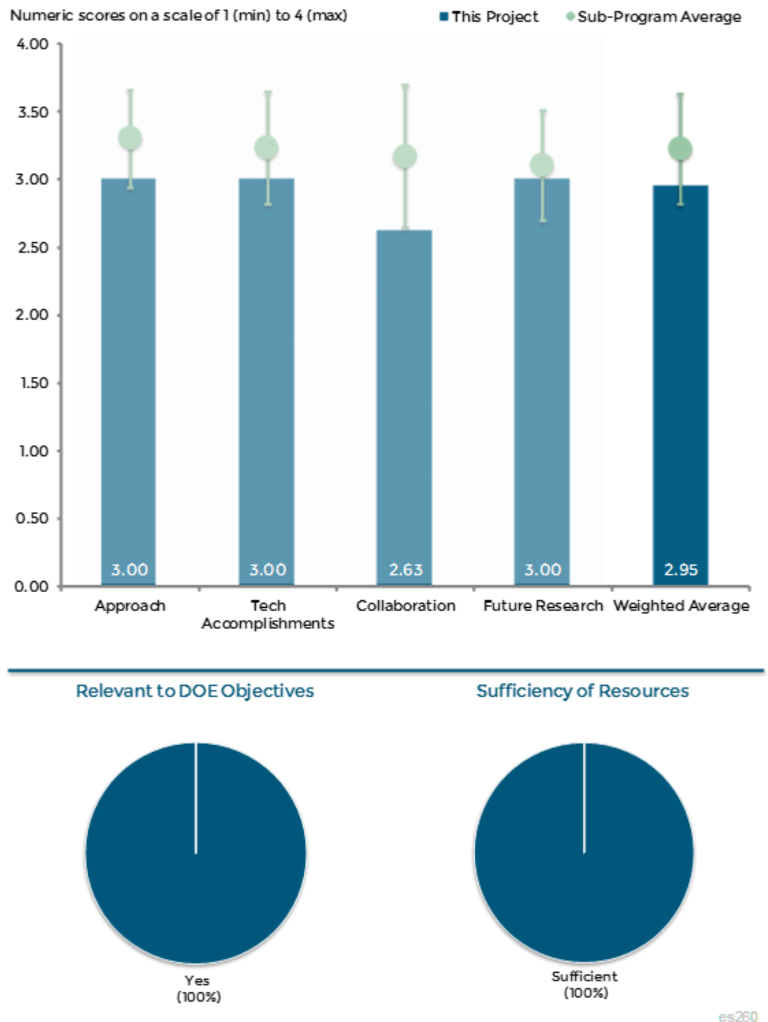


Figure 2-74 Materials Development for High-energy High Power Battery Exceeding PHEV-40 Requirements: Jane Rempel (TIAX) - Electrochemical Energy Storage

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer believed it is very difficult to solve the technical issues when a supplier is working with the powder in another company. However, the authors have done a good job in this area and have shown very interesting progress in terms of cathode and anode capacity.

Reviewer 2:

The reviewer reported that as with many of the programs that include the optimization of a high-capacity cathode and Si based anode, the cathode work in this project is much further along. The CAM-7 material appears to have been given a modest performance improvement through material optimization. The reviewer went on to say that the Si anode portion of the program is less clear, for at the moment, it appears to be a screening program aimed at developing the empirical relationships between various material and electrochemical options. The reviewer stated that it was thought that it is difficult to assess the program in it is own right, as the program appears to be taking proprietary anode materials from various sources and simply characterizing them for behavior. The quality of the work appears to be quite acceptable, and so, is not an issue.

Reviewer 3:

The reviewer explained that the principal approach of using Ni-rich cathode material and Si based anode material is reasonable, but taking into account that the contractor is following this development path for the cathode material since many years, a clear strategy or approach is not obvious on how to improve the material to meet the targets. On the anode side, there is no explanation how to finally decide on the material or to further develop the materials.

Reviewer 4:

The reviewer stated that the approaches main strategy is doping for cathode and Nano-sized composite for the anode. Even though they are typical approaches, it is not clear they are unique approaches for solving the related problems. Also, the reviewer added that the project team is mainly relying on the vendors' materials. An optimization process may be needed rather than trying via trial and error.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer reported that that the project team's progress has been good, for the authors showed good data, but at some point, the authors should provide additional information related to the powders they are using. If not, or because of proprietary information that cannot be disclosed, the authors should provide some information on how reproducible the data is that they can obtain from the different suppliers, and how reliable are those products.

Reviewer 2:

The reviewer explained that as per the approach discussion, a modest improvement of the CAM-7 material was demonstrated and is a solid accomplishment. It is less clear that contributions to the anode field have been produced. The reviewer perceived that everyone is testing everyone else's proprietary materials, and that they are all coming up with the same empirical conclusions, but with little fundamental progress in the field. The reviewer stated that this work is a quite a solid version of that progress, and that this comment is not negative for this particular discussion. This is more of a comment in terms of a high-level view of the variety of work that is occurring.

Reviewer 3:

The reviewer commented that some conclusions are quite general, such as that the lower capacity materials exhibit longer cycle life without loss of Si contact, and that capacity retention and Coulombic efficiency decrease at higher Si levels. The lower voltage cutoff can also be increased in full cells to improve cycle life, however, it leads to reduction in cathode utilization. The reviewer also stated that the project team may need to plan some strategy rather than trying combination of materials from different vendors.

Reviewer 4:

The reviewer reported that some progress was made with the lithium nickel oxide (LNO) material, however the results are still far behind the target. Moreover, most half-cell investigations stop at 4.2 V, which will lead to cell cut-off voltage even below 4.2 V, and this will not fulfill the capacity targets and the cycling results might not be very meaningful. It is also recommended to include a side-by-side comparison of the TIAX LLC material with a standard nickel-rich NMC. The reviewer also stated that in the SI-based anode development, no clear strategy can be seen to meet the targets for the results show minor improvements on cycle life but do on the expense of capacity. No detailed analysis of the degradation mechanisms and possible modifications towards substantial improvements were given. The reviewer went on to say that milestone overview only states as scheduled, and it is unclear which milestones are completed and which have been missed, and also see es209.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that the project team's collaboration with other groups does not seem to be a strong point, and the authors already explained the reasons. There is hope that in the future that involved researchers will be able to get additional insights.

Reviewer 2:

The reviewer explained that the project is lacking support from academic institutions and research centers, and the know-how input by the suppliers cannot be judged with the present data. It would be a probable advantage to establish a collaboration with one of the Si-material suppliers and/or cell manufacturers in order to ensure the progress in this field and to make the program successful.

Reviewer 3:

The reviewer stated that the project team's main collaborators are material suppliers, and it can be expected that there will be some limitations in the exchanging of data and outcomes, which also hinders closer collaborations.

Question 4: Has the project effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer explained that the approach mentioned by the authors seems appropriate, for the team will finalize cathode composition, continue with optimizations, and continue with tests based on 18650 cells. In the future, the authors should say something about electrode fabrication. The reviewer expressed a need to understand how difficult it is to scale up a pasting process with these new Si-containing anodes, for example. The reviewer asked how difficult is the pre-lithiation process, is it scalable, and how labor intensive.

Reviewer 2:

The reviewer commented that the proposed future work is repeating the milestone but does is state which specific research activity is started to improve the materials and finally cell performance. With only a few months left in the program, it is unlikely that the project will reach all milestones and targets.

Reviewer 3:

The reviewer stated that the power capability must be considered, for the demonstrated cycling performance is still not impressive.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer said that yes, the project very much supports the overall DOE objective of petroleum displacement. The study on high-energy cathodes and anodes are definitely in the right direction.

Reviewer 2:

The reviewer commented that the high-capacity cells are a critical component to the DOE's development path.

Reviewer 3:

The reviewer remarked that yes, the development of a high-capacity cathode material would enable higher energy density batteries and automotive packs.

Reviewer 4:

The reviewer noted that the high-energy-density and power-density battery systems are necessary for the achievement of the DOE objectives.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented that it is hard to know if the resources are insufficient without knowing additional details about the working relationships the authors have with the different suppliers.

Reviewer 2:

The reviewer noted that no detailed information about budget is provided.

Acronyms and Abbreviations

3D	Three Dimensional
ABR	Advanced Battery Research
AC	Alternating current
ADP	Advanced drying process
Ah	Ampere-hour
ALD	Atomic Layer Deposition
AlF_3	Aluminum fluoride
AMR	Annual Merit Review
ANL	Argonne National Laboratory
ARK	Abuse Reaction Kinetics
ARL	Army Research Lab
ARPA-E	Advanced Research Projects Agency - Energy
ATR	Attenuated Total Reflectance
BATT	Batteries for Advanced Transportation Technologies
BES	Office of Basic Energy Sciences
BMR	Battery Materials Research
BMS	Battery Management System
BNL	Brookhaven National Laboratory
C	Carbon
CAD	Computer-aided design
CAE	Computer-aided engineering
CAEBAT	Computer-aided engineering of batteries
CAFE	Corporate Average Fuel Economy
CAMP	Cell Analysis, Modeling, and Prototyping
CEI	Cathode electrolyte interphase
CG	Concentration gradient
CMC	Carboxymethyl Cellulose

CNT	Carbon Nanotubes
Co	Cobalt
Cr	Chromium
CSTR	Continually stirred tank reactor
Cu	Copper
DC	Direct current
DCR	Direct current resistance
DFT	Density Functional Theory
DoD	Depth of discharge
DOE	Department of Energy
DPP	Dynamic particle-packing
DSC	Differential Scanning Calorimetry
EA	Ethylene acrylic
EC	Ethylene Carbonate
ECT	Electrochemical-Thermal Coupling
EDM	Electrode domain model
EDS	Energy Dispersive X-ray Spectroscopy
EELS	Electron Energy Loss Spectroscopy
EIS	Electrochemical Impedance Spectroscopy
EOL	End-of-life
EPA	U.S. Environmental Protection Agency
EPR	Electron Paramagnetic Resonance
EV	Electric Vehicle
EXAFS	Extended X-ray Absorption Fine Structure
F	Fluorine
FC	Fluorocarbon
FCG	Full concentration gradient
Fe	Iron

FEC	Fluorinated ethylene carbonate
FOA	Funding Opportunity Announcements
FTE	Full-time equivalent
FTIR	Fourier Transform Infrared Spectroscopy
FY	Fiscal Year
GM	General Motors
GREET	Greenhouse Gas, Regulated Emissions, and Energy Use in Transportation
HA	Hydrothermal assisted
HCMR	High capacity manganese rich
HEV	Hybrid Electric Vehicle
HF	Hydrofluoric acid
HOMO	Highest occupied molecular orbital
HR	High-resolution
HRSXRD	High-resolution Synchrotron X-ray Diffraction
HRTEM	high-resolution transmission electron microscopy
HVE	High-voltage fluorinated electrolyte
HVM	High-volume Manufacturing
ICE	Internal combustion engine
ICL	Initial capacity loss
IE	Ion exchange
INL	Idaho National Laboratory
IR	Infrared
JCESR	Joint Center for Energy Storage Research
JCI	Johnson Controls, Inc.
kg	Kilogram
LBNL	Lawrence Berkeley National Laboratory
LCA	Life cycle assessment
LCO	Lithium Cobalt Oxide

LEESS	Lower-Energy Energy Storage System
LFO	Lithium Iron Oxide
LFP	Lithium Iron Phosphate
Li	Lithium
Li_2MnO_3	Lithiated transition metal oxides
Li_2ZrO_3	Lithium zirconate
LIB	Lithium Ion Battery
$LiBF_4$	Lithium tetrafluoroborate
LiBOB	Lithium bis(oxalate)borate
LIBS	Laser-induced breakdown spectroscopy
Li-ion	Lithium Ion
$LiPF_6$	Effective electrolyte salt for lithium-ion battery
LiPON	Lithium Phosphorous Oxynitride
LiTFSI	Lithium Bis(Trifluoromethanesulfonyl)Imide
LL	Layered lithium
LLC	Layered-layered spinel composite
LMNO	Ni-substituted manganese spinel oxides
LMO	Lithium Manganese Oxide
LMR	Lithium Manganese Rich
LOMO	Lowest occupied molecular orbital
LT	Low Temperature
MD	Machine direction
MECT	Mechanical electrochemical-thermal
Mg	Magnesium
MIT	Massachusetts institute of Technology
MLD	Molecular layer deposition
Mn	Manganese
MOSS	Multi beam optical stress sensor

Mo_2C	Molybdenum Carbide
MS	Mass spectroscopy
NaOH	Sodium hydroxide
NCA	Battery cathode material (nickel cobalt aluminum oxide)
NCM	Nickel Cobalt Manganese
ND	Neutron diffraction
NERSC	National Energy Research Scientific Computing Center
NDE	Non-Destructuve Evaluation
Ni	Nickel
NMC	Nickel Manganese Cobalt oxide
NMP	N-Methylpyrrolidone
NMR	Nuclear Magnetic Resonance
NREL	National Renewable Energy Laboratory
NYBEST	New York Battery and Energy Storage Technology Consortium
O_2	Oxygen
OAS	Open architecture standard
OCV	Open-circuit voltage
OEM	Original equipment manufacturer
ORNL	Oak Ridge National Laboratory
P	Phosphorous
PAN	Polyacrylonitrile
PCA	Principal component analysis
PEO	Polyethylene oxide
PEV	Plug-in Electric Vehicle
PHEV	Plug-In Hybrid Electric Vehicle
PI	Principal Investigator
PPy	Polypyrrole
PVDF	Polyvinylidene difluoride

QC	Quality Control
R&D	Research and Development
RFPI	Request for proposal information
ROI	Return on investment
RT	Room temperature
Ru	Ruthenium
S	Sulfur
Sb	Antimony
SEI	Solid Electrolyte Interface
SEM	Scanning Electron Microscope
SFG	Sum frequency generation
Si	Silicon
SIMS	Secondary ion mass spectrometry
SiO_2	Silicon dioxide
SLMP	Stabilized lithium metal powder
Sn	Tin
SNL	Sandia National Laboratory
SOC	State of Charge
STEM	Scanning transmission electron microscopy
SXAS	Soft X-ray absorption spectroscopy
TD	Transverse direction
TEM	Transmission Electron Microscope
Ti	Titanium
TM	Transition Metal
TMA	Tri Methyl Aluminum
TOF	Time of flight
TR-XRD	Time-resolved X-ray diffraction
TXM	Transmission x-ray microscope

USABC	US Advanced Battery Consortium
USCAR	U.S. Council for Automotive Research
V	Vanadium
V	Volts
VC	Vinylene Carbonate
VIBE	Virtual Integrated Battery Environment
VOC	Volatile organic compounds
VTO	Vehicle Technologies Office
Wh	Watt hour
XANES	X-ray Absorption Near Edge Spectroscopy
XAS	X-ray Absorption Spectroscopy
XPS	X-ray Photoelectron Spectroscopy
XRD	X-ray Diffraction (Crystallography)
XRF	X-ray Fluorescence

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3. Electric Drive Technologies

Electric drive technologies, including the electric motor, inverter, boost converter, and on-board charger, are essential components of hybrid and plug-in electric vehicles (PEV) propulsion systems. The U.S. Department of Energy (DOE) Vehicle Technologies Office (VTO) supports research and development (R&D) to reduce the cost and improve the performance of innovative electric drive devices, components, and systems. Reducing the cost of electric drive vehicles is essential for increasing consumer adoption and meeting the *EV Everywhere* Grand Challenge goal of making the U.S. the first nation in the world to produce PEVs by 2022 that are as affordable for the average American family as gasoline-powered vehicles in 2012.

VTO funds research to advance electric drive technologies in two key areas:

- Power electronics
- Electric motors

VTO funds research on electric drive technologies to:

- Reduce cost, weight, and volume;
- Improve performance, efficiency, and reliability;
- Develop innovative modular and scalable designs; and
- Improve manufacturability and accelerate commercialization.

In addition, VTO is also supporting research on propulsion materials to lower adoption barriers for electric drive technologies that face specific material limitations. More information on these research and development activities can be found in the Annual Merit Review and Annual Progress Reports.

VTO works extensively with a number of different organizations. The electric drive technologies subprogram supports a number of unique user facilities at the national laboratories. Within DOE, the office collaborates with the Office of Science, ARPA-e (Advanced Research Projects Agency-Energy), and the Clean Energy Manufacturing Initiative. Across the federal government, the subprogram works with:

- The National Network for Manufacturing Innovation
- The Interagency Advanced Power Group
- The U.S. Army Tank, Automotive Research and Development and Engineering Center (Department of Defense).

Much of the subprogram's research is conducted in sync with industry partners through:

- The U.S. DRIVE Partnership focusing on light-duty vehicles
- The 21st Century Truck Partnership, focusing on heavy-duty vehicles.

As described in the *EV Everywhere* Blueprint, the major goals of the subprogram are to reduce the cost of electric drive systems by half and decrease their volume by one-third by 2022.

Subprogram Feedback

DOE received feedback on the overall technical subprogram areas presented during the 2015 Annual Merit Review (AMR). Each subprogram technical session was introduced with a presentation that provided an overview of subprogram goals and recent progress, followed by a series of detailed topic area project presentations.

The reviewers for a given subprogram area responded to a series of specific questions regarding the breadth, depth, and appropriateness of that DOE VTO subprogram's activities. The subprogram overview questions are listed below, and it should be noted that no scoring metrics were applied. These questions were used for all VTO subprogram overviews.

Question 1. Was the program area, including overall strategy, adequately covered?

Question 2. Is there an appropriate balance between near- mid- and long-term research and development?

Question 3. Were important issues and challenges identified?

Question 4. Are plans identified for addressing issues and challenges?

Question 5. Was progress clearly benchmarked against the previous year?

Question 6. Are the projects in this technology area addressing the broad problems and barriers that the Vehicle Technologies Office (VTO) is trying to solve?

Question 7. Does the program area appear to be focused, well-managed, and effective in addressing VTO's needs?

Question 8. What are the key strengths and weaknesses of the projects in this program area? Do any of the projects stand out on either end of the spectrum?

Question 9. Do these projects represent novel and/or innovative ways to approach these barriers as appropriate?

Question 10. Has the program area engaged appropriate partners?

Question 11. Is the program area collaborating with them effectively?

Question 12. Are there any gaps in the portfolio for this technology area?

Question 13. Are there topics that are not being adequately addressed?

Question 14. Are there other areas that this program area should consider funding to meet overall programmatic goals?

Question 15. Can you recommend new ways to approach the barriers addressed by this program area?

Question 16. Are there any other suggestions to improve the effectiveness of this program area?

Responses to the subprogram overview questions are summarized in the following pages. Individual reviewer comments for each question are identified under the heading Reviewer 1, Reviewer 2, etc. Note that reviewer comments may be ordered differently; for example, for each specific subprogram overview presentation, the reviewer identified as Reviewer 1 in the first question may not be Reviewer 1 in the second question, etc.

Subprogram Overview Comments: Steven Boyd (U.S. Department of Energy) – edt000

Question 1: Was the program area, including overall strategy, adequately covered?

Reviewer 1:
The reviewer said that the DOE Vehicle Technologies Office (VTO) Electric Drive Technologies program and strategy was adequately covered in this presentation. The program goal was clearly identified and the strategy as to how the problem was being solved was presented. The reviewer said that the overall strategy is to develop technologies and designs to reduce the cost, improve the performance, and increase the reliability of power electronics, electric motors, and other electric propulsion components. The reviewer said that this task is split into a research and development (R&D) area and a Funding Opportunity Announcement (FOA) area with the goal of the R&D results feeding the FOA projects. The R&D tasks are focusing on wide bandgap (WBG) development and reducing rare earth magnets in motors, both required to meet the program goals. The end result is specified along with the steps required to achieve it. The reviewer found that overall, the program area was very well covered.

Reviewer 2:
The reviewer said yes.

Reviewer 3:
The reviewer said yes, the program overview was effective and the overall strategy clearly explained and the justification of pursuing the proposed strategy clearly explained as well.

Reviewer 4:
The reviewer said yes, the program area and strategy are well directed.

Reviewer 5:
The reviewer said yes. The reviewer elaborated that cost and technical targets were clearly explained and the program's strategy and progress were highlighted well.

Reviewer 6:
The reviewer said that the program area and overall strategy was well covered and it is clear to the audience what the program is working on.

Question 2: Is there an appropriate balance between near- mid- and long-term research and development?

Reviewer 1:
The reviewer remarked yes, it does have appropriate balance.

Reviewer 2:
The reviewer said yes.

Reviewer 3:
The reviewer said yes. The reviewer detailed that some of the research efforts, such as WBG semiconductors and novel motor designs, can have immediate impacts. Other areas, such as magnetic materials development, are much needed long-term endeavors.

Reviewer 4:
The reviewer said yes. The reviewer detailed that the program strategy includes: meeting the Electric Vehicle (EV) Everywhere Grand Challenge, a 10 year goal; WBG semiconductor-related technologies, including packaging, converter, and system technologies that have near-, mid-, and long-term R&D outcomes; non rare-earth motor R&D, which is a mid- to long-term research goal based on the need to re-think business strategies in response to disruptions in the market of rare-earth magnets; and near- to mid-term industrial R&D in inverters and motors.

Reviewer 5:
The reviewer detailed that the projects presented during the Annual Merit Review included projects nearing conclusion, projects in the middle of development, and new projects. These projects included both R&D and FOA projects. The reviewer described that this presentation also included previous projects that had successfully transitioned to production or had been licensed for further development. Some of the projects are addressing specific issues or single components, but are related in terms of providing a solution to the overall problem. The reviewer noted that other tasks are related to new architectures that will use the projects of today to deliver more efficient and cost effective vehicles in the future.

Reviewer 6:
The reviewer said yes, there is a very good balance between near-, mid-, and long-term R&D. The reviewer's suggestion is to start a new cycle of projects that are fairly mid- to long-term to keep pushing the state of the art.

Question 3: Were important issues and challenges identified?

Reviewer 1:
The reviewer said yes.

Reviewer 2:
The reviewer said absolutely, and clarified that the program develops targets for the improvement of electric drive system components (cost, size, weight, and loss), as needed to meet the EV Everywhere Grand Challenge goals of reduced cost, size, weight, and cost.

Reviewer 3:
The reviewer agreed that the challenges in terms of specific power density, efficiency and cost were clearly identified.

Reviewer 4:
The reviewer said yes, and elaborated that a primary challenge for electric drive technologies is cost reduction.

Reviewer 5:
The reviewer said that the presentation did a very good job of identifying the leading issues/challenges facing the electric vehicle development world. The research in the area of reducing/eliminating rare-earth magnetics is a very good example. The reviewer detailed that the supply of these magnetics is limited and therefor the price is highly volatile, while the development of a magnet from more abundant materials and motor designs that can effectively use it will enable a more cost effective system to be produced. The reviewer identified he development of WBG switches as a challenging area. These devices are capable of very fast switching, but this brings a host of other challenges: how these devices are driven/controlled; how the heat is removed; and how these devices are packaged, to name a few.

Reviewer 6:
The reviewer said yes.

Question 4: Are plans identified for addressing issues and challenges?

Reviewer 1:
The reviewer said yes. The program includes R&D focus areas in adoption of WBG semiconductors and their application, and in development of non-rare-earth motors.

Reviewer 2:
The reviewer said that several plans were identified for cost reduction, including the adoption of WBG semiconductors and motor technologies that do not use rare-earth magnets.

Reviewer 3:
The reviewer said that the projects in the two main areas of focus were clearly identified in the presentation. The goal as well as the expected results were documented, and the current status of these projects was shown. The reviewer remarked that it was clear that significant effort has been aimed at these areas and results were seen with more advances to come.

Reviewer 4:
The reviewer said yes.

Reviewer 5:
The reviewer said yes.

Reviewer 6:
The reviewer said that it is clear how ongoing programs are trying to address these challenges, but with several of the current programs are coming to an end within the next year or two, and it was not very clear what the next batch of projects will target.

Question 5: Was progress clearly benchmarked against the previous year?

Reviewer 1:
The reviewer said yes, very much so.

Reviewer 2:
The reviewer said yes.

Reviewer 3:
The reviewer said that results were clearly highlighted, although it was necessary to dig a little to identify this year's new results relative to last year's. Most projects in the program are very good in this regard, while a few are vague in identifying and benchmarking their results.

Reviewer 4:
The reviewer noted that several research accomplishments were clearly presented. However, it was not obvious to this reviewer that they were accomplished since the previous year. The reviewer indicated that after reviewing the 2014 presentation, the accomplishments appear to be recent.

Reviewer 5:
The reviewer remarked to some extent, but it would be good to show quantitatively how the various projects are progressing the various performance metrics/targets

Reviewer 6:
The reviewer said that this presentation did not specifically benchmark progress relative to last year with the exception of the current status on Slide Seven, which indicated $12/kW while last year it was at $15/kW versus the goal of $8/kW. The presentation concentrated on what was accomplished this year, which was significant.

Question 6: Are the projects in this technology area addressing the broad problems and barriers that the Vehicle Technologies Office (VTO) is trying to solve?

Reviewer 1:
The reviewer remarked yes, clearly identified.

Reviewer 2:
The reviewer said yes, very important barriers for the VTO.

Reviewer 3:
The reviewer said yes, these projects are the primary barriers to reducing cost and increasing performance of electric drive technologies.

Reviewer 4:
The reviewer said yes, the program has a diversified set of programs that address many of the identified barriers

Reviewer 5:
The reviewer said yes, and elaborated that the projects target reductions in the cost, size, weight, and loss of the electric drive systems of electric vehicles, which are key barriers to the EV Everywhere Grand Challenge.

Reviewer 6:
The reviewer said that the projects are focused on solving specific issues by providing not only specific issues but also providing the tools and knowledge necessary to adapt these solutions to meet the needs of an individual problem. The projects are focused on how to use a device, create a common sub-component, such as a capacitor, or a process to design, and effective thermal system that can be used or modified by different industry suppliers to meet their product needs. The reviewer said that in the motor area, non-rare earth magnetics with specific properties are being developed as well as motor topologies that are capable of using these magnets to meet performance goals. Other projects are addressing new and novel electric traction system implementations featuring higher levels of integration or more user friendly charging techniques.

Question 7: Does the program area appear to be focused, well-managed, and effective in addressing VTO's needs?

Reviewer 1:
The reviewer said yes, the program is focused and well-managed. The key challenge is the strategic planning part to ensure that future projects will continue to be relevant and address the key challenges and barriers.

Reviewer 2:
The reviewer said yes, and elaborated that several key barriers have been identified and multiple research projects are addressing each area.

Reviewer 3:
The reviewer said yes, the program is well managed. The reviewer explained that over the past few years this reviewer has seen programs stopped that were not making progress toward the documented goals as well as projects that have made it to real world production. The reviewer confirmed that all of the projects are related to solving the EV Everywhere Grand Challenge. Some are more high-risk but with big payoffs than others, but all are focused on the end goal.

Reviewer 4:
The reviewer said yes.

Reviewer 5:
The reviewer said yes.

Reviewer 6:
The reviewer said yes.

Question 8: What are the key strengths and weaknesses of the projects in this program area? Do any of the projects stand out on either end of the spectrum?

Reviewer 1:

The reviewer said that the projects supported by VTO covers the most important technologies in electric vehicles and VTO is pushing for both technology advancement and cost reduction. The reviewer expressed concern that the available funding may not be sufficient to solve the targeted problems.

Reviewer 2:

The reviewer identified two projects that stood out: the funding of the Delphi Viper module, which is being integrated into the 2016 Chevy Volt using silicon devices; and Next Generation Wide Bandgap Packaging Improves Inverter Efficiency (Oak Ridge National Laboratory [ORNL]). What is attractive about these two projects are the focus on improved packaging of silicon carbon (SiC) power devices for automotive inverters, and the direct involvement of a Tier One (Delphi) automotive supplier.

Reviewer 3:

The reviewer believed that the shotgun approach to pursuing multiple approaches to meet well-defined overall goals is a good one. DOE's role should indeed be one of pursuing a portfolio of projects in which some have high risk but high potential reward. The reviewer identified the capacitor technology direction of the past few years as a good example. All of the several projects have been well directed, and this year it appears that at least one of them is going to be a winner that could have a significant impact on EV technology (and on other industries as well).

The reviewer explained that the recent projects in electronic packaging have spanned a wide range of quality: some have had a significant impact on wide bandgap modules for the industry, or have led to fundamental new understandings that can have a future impact. For others, the results have been vague. The reviewer noted that the projects in inverters and chargers, and in machines, appear to be going well so far. These span a wide range from shorter-term industrial projects to longer-term projects at laboratories or universities, which is appropriate. The work in non-rare-earth magnets should be continued.

Reviewer 4:

The reviewer commented that wide-bandgap semiconductors are becoming mainstream, but still require some development in the packaging area to reliably operate at high temperatures. Capacitor technologies are the next big issue in power electronics systems. The reviewer noted that moving away from rare-earth magnets in motors is also a key area to reduce cost. The majority of projects are addressing these areas. Understandably, the program focuses on near- to mid-term issues, but the reviewer would like to see a few more long-term research efforts.

Reviewer 5:

The reviewer said that the key strengths of the projects are that they are well-diversified and almost all of them build prototypes and provide experimental results. The reviewer said that the key weakness is that these projects need to be tied together and optimized at the system level to evaluate the realistic improvement at the system level.

Reviewer 6:

The reviewer said that the key strength is that all of these projects are aimed at solving a common problem but are attacking different areas to achieve a common solution. The use of WBG devices will create challenges in terms of how to drive power devices at high switching frequencies and still maintain fault protection, what are the package requirements to enable high temperature, reliable operation and still support high switching speeds, how do you maintain operating temperatures in a safe range all while lowering the overall cost of the system and increasing the efficiency. The reviewer noted that the projects identified are addressing these issues in such a way that the industry supplier still has freedom to implement the system in accordance with their internal design rules. According to the reviewer, the weakness is in areas that are broader in nature such as new system topologies. These projects are beneficial in that they are challenging the status quo in terms of what the system implementation should be but do not always address all of the issues or minimize the impact on the individual components. Even these projects have benefits to the overall program in forcing a re-thinking of the status quo.

Question 9: Do these projects represent novel and/or innovative ways to approach these barriers as appropriate?

Reviewer 1:

The reviewer said yes, and explained that the ORNL effort allows the use of additive manufacturing, advanced packaging techniques, to improve power density with SiC. The Delphi Viper module is perhaps one of the best chances the United States has for a domestic Tier One automotive supplier to lead development of future electric vehicles.

Reviewer 2:

The reviewer said that yes, most of the projects are innovative and try to address the barriers.

Reviewer 3:

The reviewer said in general, yes.

Reviewer 4:

The reviewer said yes, the projects provide novel solutions to the program's targets.

Reviewer 5:

The reviewer said that using additive printing on the development of a SiC based inverter was novel and innovative – it provided a quick path to demonstrate the design. While not ready for high-rate production this does provide a path to enable fast turnaround on early development projects whether they are the R&D or the production world. The reviewer noted that several of the motor projects represent very innovative approaches to motor design without rare earth magnets and are showing excellent promise of replacing rare earths. Other projects are developing novel methods for cooling components, testing them, and in the development of manufacturing processes. The reviewer thinks that most of the projects are novel/innovative in their approach, their solutions or both.

Reviewer 6:

The reviewer said the projects do balance the innovation and practical feasibility.

Question 10: Has the program area engaged appropriate partners?

Reviewer 1:

The reviewer said yes, there are many projects with multiple partners across the supply chain.

Reviewer 2:

The reviewer said yes, efforts appeared to involve leading suppliers across the supply chain. SiC device manufacturers (not specified, but assumed Cree), module teams (APEI module shown), Tier One automotive suppliers (Delphi), and original equipment manufacturers (Chevrolet).

Reviewer 3:

The reviewer said yes, the program engages a wide range of relevant partners from industry, academia and national laboratories.

Reviewer 4:

The reviewer said yes, and explained that teams are emphasized throughout the program, which include companies, national laboratories, and universities.

Reviewer 5:

The reviewer said yes, and detailed that the program has a wide range industry, federal agency, academia, and national laboratory affiliations.

Reviewer 6:
The reviewer found that the teams have the appropriate partners for their specific project. Some of the collaboration partners may not be fully utilized during the entire project but are available when needed. The reviewer highlighted that in some cases, the teams may be lacking a specific expertise or have not identified the need for it yet, and this is pointed out during the review process. In general, the teams consist of the necessary people and appear to be effectively using this expertise.

Question 11: Is the program area collaborating with them effectively?

Reviewer 1:
The reviewer commented that based on the progress of the various projects this reviewer thinks the program area is effectively collaborating with the teams. The projects, while separate, are still working toward a common goal and there appears to be very good cooperation among the national laboratories on these projects.

Reviewer 2:
The reviewer said yes.

Reviewer 3:
The reviewer said yes.

Reviewer 4:
The reviewer said yes.

Reviewer 5:
The reviewer said generally yes, and detailed that the aluminum-nickel-cobalt (AlNiCo) collaboration appears to be a good example of collaboration.

Question 12: Are there any gaps in the portfolio for this technology area?

Reviewer 1:
The reviewer said none observed.

Reviewer 2:
The reviewer said that the portfolio makes sense.

Reviewer 3:
The reviewer did not notice any gaps.

Reviewer 4:
The reviewer is not aware of any gaps.

Reviewer 5:
The reviewer suggested more system level projects tying the various components together, more focus on enabling technologies including magnetic materials and thermal management but in the context of actual components, and more focus on true tight integration of the motor and power electronics especially enabled by WBG devices.

Reviewer 6:
The reviewer commented that the largest observed gap is regarding cost-effective connectors for high-voltage power that meets automotive requirements. The reviewer is not sure if this is even appropriate for this forum, but that is the one area where the reviewer has not seen any advances – typically use lug terminals, which are okay, but connectors would enable faster assembly at the vehicle level but need to perform in all areas – safety, weather protection, and cost. The reviewer presently believes the portfolio is adequate but as the development of WBG-based power electronics advances there may be some new areas that will need addressing. The reviewer is sure that these areas will be addressed in future projects as appropriate.

Question 13: Are there topics that are not being adequately addressed?

Reviewer 1:

The reviewer is not aware of any topics not being adequately addressed.

Reviewer 2:

The reviewer concluded that the primary technical barriers are being adequately addressed.

Reviewer 3:

The reviewer said that the program should continue to solicit new research directions that are outside the current thinking, but there are no glaring oversights in directions.

Reviewer 4:

The reviewer recommended that more involvement of automotive Tier One suppliers in WBGs is needed. Globally, it will be Delphi, Bosch, Magna, Denso, and others that lead the introduction of SiC into electric vehicles. The reviewer noted that Toyota has already announced SiC will be in the Prius by model year 2020.

U.S.-based Tier One suppliers like Delphi and Magna can supply OEM's around the world with SiC or gallium nitride (GaN)-based power systems, from inverters, direct current-direct current (DC-DC) converters, and on-board chargers. The reviewer observed that in some cases Tier Two suppliers or OEM's may also directly use the WBG in their systems, but the Tier One suppliers will have the biggest impact, and must be more actively involved in the introduction of SiC domestically for the drivetrain to match efforts ongoing in Japan and Germany primarily.

Reviewer 5:

The reviewer believes that some of these areas are addressed but the level of effort is not adequate.

Reviewer 6:

The reviewer thinks that the only topic that is not being adequately addressed is integrating these systems in the vehicle but this is typically the responsibility of the OEM. The reviewer’s concern is that the integration will have a significant effect on the implementation of the system – how much space is available, what shape, etc. The reviewer sees generic requirements such as voltage, power, etc. and a desire to reduce size and mass, but not much in terms of how to interface to a battery or the rest of vehicle. The reviewer noted that some of the requirements provided to the capacitor projects are not representative of some of the newer architectures: boosted systems may have a 650 volt or higher high-voltage bus while most of the capacitor programs are aimed at 600 volts or less. The reviewer is unsure if the constraints of the end-use are fully understood, such as the typical requirements for particle size in coolant systems – will the jet impingement-based cooling survive these particles or will an extra filter be required or will this work with the standard pressure/flow rate of today’s coolant systems.

Question 14: Are there other areas that this program area should consider funding to meet overall programmatic goals?

Reviewer 1:

The reviewer said no.

Reviewer 2:

The reviewer presently does not see any significant benefit to adding areas to this program. The reviewer believes the focus is on the correct areas, and this should be revisited in the coming years as electric vehicle technology progresses.

Reviewer 3:

The reviewer stated that for most electric vehicle adoption, based on Tesla, BMW, Lexus, and others, it seems like much of the initial adoption of SiC in the drivetrain is occurring at the high-end of the performance spectrum. The reviewer therefore suggests inverter targets be set with higher power levels, 100-300kW, with increased SiC die sizes, and increased involvement of Tier One suppliers. The reviewer stipulated that the higher-end vehicles normally are the first to adopt new, relatively expensive technology, and based on the Tesla model it is clear that customers will pay for high-end performance and quality electric vehicles.

The reviewer pointed out that the market is seeing strong interest, especially from Tesla and international OEM's and Tier One's, in the higher-power inverter area utilizing SiC in the drivetrain.

Reviewer 4:

The reviewer suggested more system level projects tying the various components together, more focus on enabling technologies including magnetic materials and thermal management but in the context of actual components, and more focus on true tight integration of the motor and power electronics, especially enabled by WBG devices. The reviewer also suggested fault-tolerance/limp-home mode capability aspects, and monitoring and diagnostics of the electric drivetrain components including insulation, bearings, transmission, etc.

Reviewer 5:

The reviewer suggested maybe investing in projects that can demonstrate the technical feasibility at vehicle level.

Reviewer 6:

The reviewer suggested high-frequency magnetics research for power converters could be a good addition, although that may not be a priority since other technologies are also limiting the operating frequency.

Question 15: Can you recommend new ways to approach the barriers addressed by this program area?

Reviewer 1:

The reviewer had no additional recommendations other than what was mentioned in questions 13 and 14.

Reviewer 2:

The reviewer said that the program is aligned well to the near- and mid-term barriers for electric drive technologies. The reviewer suggests increasing focus on some of the long-term areas, such as magnetic materials development.

Reviewer 3:

The reviewer suggested more system-level projects tying the various components together, more focus on enabling technologies including magnetic materials and thermal management but in the context of actual components, more focus on true tight integration of the motor and power electronics especially enabled by WBG devices. The reviewer also suggested fault-tolerance/limp-home mode capability aspects, and monitoring and diagnostics of the electric drive train components including insulation, bearings, transmission, etc.

Reviewer 4:

The reviewer emphasized that it is important to continue to emphasize cost, but very few of the projects were able to measure the real cost, because the projects constitute mid- to long-term research where the cost cannot be directly measured, only the more near-term industrial projects had a realistic chance of truly measuring cost. The reviewer underscored that this is understandable. Perhaps there should be some effort to define intermediate metrics that are related to cost but are not simply $/kW, which would help guide the mid- and long-term R&D.

The reviewer said that on the whole, the projects were more successful in quantifying performance. The goals regarding performance (weight, volume, loss) could perhaps be expanded to consider the system as a whole. The reviewer provided as examples, as noted in this year's and last year's program presentations, look for ways to expand the range of high efficiency of the overall system, or to improve the overall size and weight, rather than the inverter alone or the machine alone.

Reviewer 5:

The reviewer found that the current approach to barriers at the program level is working – barriers are being broken and progress is being made as long as the barriers being addressed at the individual project level are correct.

Question 16: Are there any other suggestions to improve the effectiveness of this program area?

Reviewer 1:

The reviewer suggested continuing to support disruptive game-changing technologies that can make a step change in the state of the art.

Reviewer 2:

The reviewer suggested the following in the electronic packaging area: continue to nurture the WBG industry to develop good power modules as appropriate for the future EV business; and focus the national laboratories on producing fundamental results, models, and tools that are useful to the industry, or in pursuing specific collaborations led by industry.

Reviewer 3:

The reviewer has no further suggestions.

Reviewer 4:

The reviewer suggested that adding additional go/no go gates to the programs with specific requirements would enable the review team to track progress and add resources as needed or stop programs that are not progressing at opportune times. This would also allow the creation of alternative approaches if deemed necessary or appropriate. The reviewer thinks that overall this process has been modified enough that it is meeting the needs of program area.

Reviewer 5:

The reviewer had no additional recommendations other than what was mentioned in questions 13 and 14.

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.

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Benchmarking EV and HEV Technologies	Burress, Tim (ORNL)	3-17	3.63	3.44	3.44	3.56	3.50
DREAM (Development of Radically Enhanced Alnico Magnets)	Anderson, Iver (Ames)	3-22	3.67	3.25	3.67	3.50	3.44
North American Electric Traction Drive Supply Chain Analysis: Focus on Motors	Whaling, Christopher (Synthesis Partners)	3-26	3.10	2.70	3.60	3.20	2.98
Next-Generation Inverter	Zhao, Zilai (General Motors)	3-30	3.38	3.25	3.19	3.38	3.29
Unique Lanthide-Free Motor Construction	Gilbert, Alan (UQM Technologies, Inc.)	3-34	3.25	3.25	3.50	3.25	3.28
Alternative High-Performance Motors with Non-Rare Earth Materials	El-Refaie, Ayman (General Electric)	3-38	3.38	3.38	3.38	3.13	3.34
Advanced Packaging Technologies and Designs	Liang, Zhenxian (ORNL)	3-42	3.07	3.00	3.07	2.93	3.02

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Electric Drive Inverter Research and Development	Chinthavali, Madhu (ORNL)	3-47	3.50	3.14	3.21	3.21	3.25
Innovative Technologies for Converters and Chargers	Su, Gui-Jia (ORNL)	3-51	3.50	3.33	3.42	3.17	3.36
Advanced Low-Cost SiC and GaN Wide Bandgap Inverters for Under-the-Hood Electric Vehicle Traction Drives	Olejniczak, Kraig (APEI Inc.)	3-55	3.25	3.33	3.25	3.08	3.27
High-Temperature DC Bus Capacitors Cost Reduction and Performance Improvements	Yializis, Angelo (Sigma Technologies International)	3-58	3.58	3.50	3.50	3.33	3.50
High-Performance DC Bus Film Capacitor	Tan, Dan (General Electric)	3-63	3.08	3.08	3.08	3.25	3.10
Cost-Effective Fabrication of High-Temperature Ceramic Capacitors for Power Inverters	Balachandran, Balu (ANL)	3-68	3.50	3.40	3.40	3.20	3.40
Non-Rare Earth Motor Development	Burress, Tim (ORNL)	3-71	3.30	3.10	3.10	3.30	3.18
Performance and Reliability of Bonded Interfaces for High-Temperature Packaging	DeVoto, Doug (NREL)	3-76	3.42	3.17	3.42	3.33	3.28

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Electric Motor Thermal Management Research and Development	Bennion, Kevin (NREL)	3-79	3.29	3.29	3.43	3.50	3.33
Brushless and Permanent Magnet Free Wound Field Synchronous Motor (WFSM)	Ludois, David (U of Wisconsin-Madison)	3-83	3.42	3.58	3.25	3.33	3.47
Traction Drive Systems with Integrated Wireless Charging	Su, Gui-Jia (ORNL)	3-88	2.83	2.67	2.83	3.33	2.81
High-Efficiency High-Density GaN-Based 6.6 kW Bidirectional On-Board Charger for PEVs	Zhu, Charles (Delta Products Corporation)	3-91	3.38	3.25	3.13	3.50	3.30
Gate Driver Optimization for WBG Applications	Ericson, Nance (ORNL)	3-94	3.38	3.38	3.13	3.38	3.34
Power Electronics Thermal Management Research and Development	Bennion, Kevin (NREL)	3-97	3.50	3.33	3.17	3.50	3.38
Thermal Performance Benchmarking †	Moreno, Gilbert (NREL)	3-100	3.20	3.00	3.10	3.20	3.09
Multi-Speed Range Electric Motor Research and Development †	Tang, Lixin (ORNL)	3-103	3.00	2.90	2.30	3.20	2.89

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
30 kW Modular DC-DC System using Superjunction MOSFETs †	Erickson, Robert (U of Colorado)	3-107	3.42	3.33	3.00	3.25	3.30
Evaluation of an APEI 88 kW SiC Inverter with Next-Generation Cree 900 V SiC MOSFET Technology for Ford Automotive Systems †	Casady, Jeffrey (Cree)	3-110	3.17	3.08	3.00	3.17	3.10
Overall Average			**3.33**	**3.21**	**3.22**	**3.29**	**3.25**

Note: † denotes poster presentation.

Benchmarking EV and HEV Technologies: Tim Burress (Oak Ridge National Laboratory) - edt006

Presenter

Tim Burress, Oak Ridge National Laboratory.

Reviewer Sample Size

A total of eight reviewers evaluated this project.

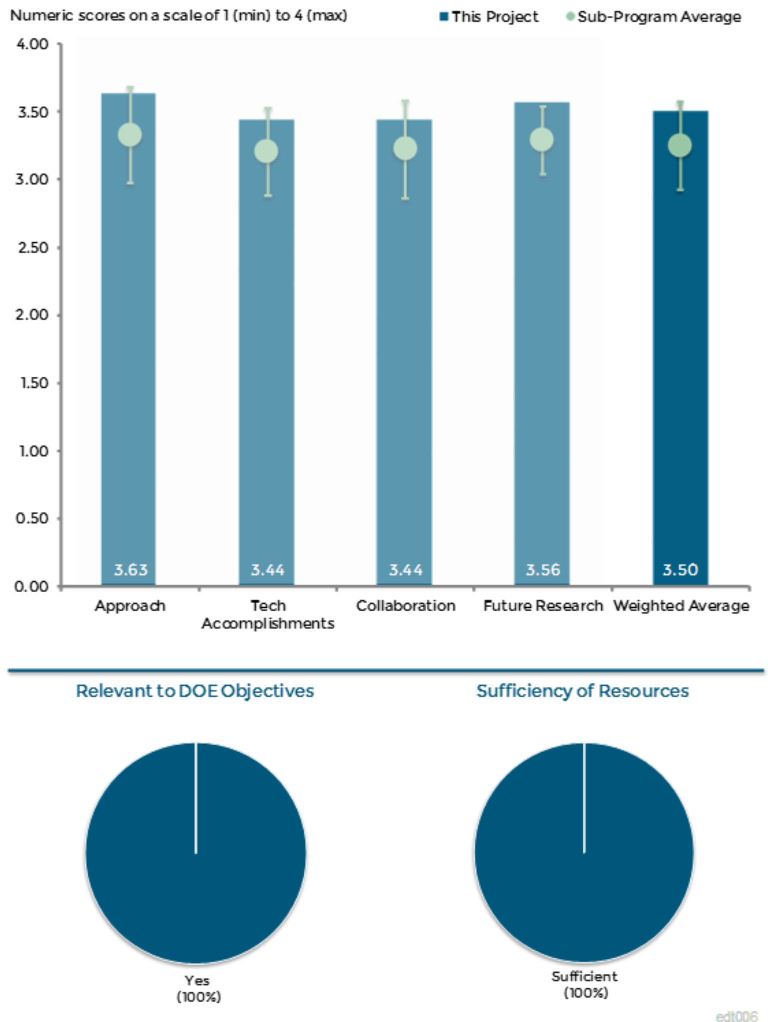

Figure 3-1 Benchmarking EV and HEV Technologies: Tim Burress (Oak Ridge National Laboratory) – Electric Drive Technologies

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer said that the approach of tearing down and benchmarking the various traction systems over the years has proved to be very effective and valuable. Many experts in the field really appreciate the various reports that come out of this effort. The reviewer noted that it provides experts with good understanding of the state-of-the art as well as a good basis of comparison of the various systems.

Reviewer 2:

The reviewer observed that this has been one of the most popular projects in the Annual Merit Review (AMR) meeting every year.

Reviewer 3:

The reviewer considered this ongoing program to be very helpful to research & development (R&D) in the United States, providing a relatively inexpensive way to educate all of us on what the competition is doing. The reviewer noted that there is necessarily some time lag in getting this information, so believed that it was good that the team was attempting to be as up-to-date as possible.

Reviewer 4:

The reviewer stated that this project aids development and verification of Department of Energy (DOE) 2020 targets. Thorough examinations of state of the art vehicle equipment provide specific goals for electric drive research efforts.

Reviewer 5:

The reviewer believed that the approach taken provides a very reasonable path to determining the state of the art for production electric drive systems for vehicles. The teardown and test results provide data that supports a thorough understanding of the evaluated system. This information enables a valid conclusion as the benefits of the approach for this particular implementation and its usefulness in other applications. The reviewer believed that the comparison chart for the various systems that have been evaluated using this approach was very informative. Based on the chart, the second and third generation systems with higher power levels are approaching the 2020 DOE targets. This person concluded that the tasks and timeline are appropriate for the stated objectives.

Reviewer 6:

The reviewer stated that the tear down work is great as always, but would have liked to see an improvement on how the data is presented. This person thought a visualization of the outcomes, current and past, would have spoken volumes to ongoing trends, weaknesses, progress, etc. The reviewer suggested that the presenters need to move beyond Excel tables.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer thought that the number of systems that had been benchmarked so far was impressive, and that the effort seemed to be fairly keeping up to date with the various traction systems that continue being rolled out.

Reviewer 2:

The reviewer appreciated the previous work on Toyota vehicles, which has been quite influential for the rest of us. This person found this year's emphasis on the 2014 Honda Accord and the upcoming BMW i3 to be very well directed.

The reviewer asked the project team to please be sure to include efficiency contours and detailed data for the boost converter in systems containing an intermediate direct current (DC) link, such as the Honda Accord. This is needed to complete the characterization of the system.

Reviewer 3:

The reviewer saw that the project's technical goals appeared to be on track, and thought that the work looks very good. One technical challenge is interfacing Oak Ridge National Laboratory’s (ORNL)'s control and test equipment with original equipment manufacturers (OEM) components. The group seems well equipped to deal with the issue and commence testing soon.

Reviewer 4:

The reviewer reported that the project has provided lots of information on current commercial hybrid electric vehicle (HEV) power electronics.

Reviewer 5:

The reviewer’s assessment of progress of this project was that it has been consistently excellent. The systems are obtained, examined, tested, torn down, and the results documented per the timeline. The teardown reports are thorough and provide insight into the design/performance goals of the supplier. The details provided from the teardown are useful and well documented. The reviewer noted, however, that the presentation did not provide an explanation as to why the boost converter switches were imbalanced: two on top versus three on the bottom, which would have been useful, and suggested including this in the final report. This person thought the presentation did a very good job of documenting the teardown of the components and the relationships between the components but lacked an overview of the system as installed in the vehicle. The use of a standard test procedure with specific operating points and known software provides an easy way to compare the different suppliers’ systems. The reviewer believes that this is a reasonable and efficient approach to test the hardware rather than try to use the system software from the supplier. In conclusion the reviewer was asked if there was any testing of the safety performance of the systems such as high-voltage (HV) discharge times, the use of high voltage interlocks, etc.

Reviewer 6:
The reviewer decided that good progress has been made thus far, but requested clarification on the capabilities ORNL offers that a major OEM could not do themselves.

Question 3: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer thought that the BMW i3 was an excellent choice for the next one.

Reviewer 2:
The reviewer agreed that examination of the BMW will be quite interesting as BMW is known to be very focused on this area.

Reviewer 3:
The reviewer saw good, diversified proposed future work targeting different vehicles and different components within the electric drive train.

Reviewer 4:
This reviewer estimated the work for fiscal rear (FY) 2015 to be on track. Several technical barriers were identified, but the team seems well equipped to address them and complete the project.

Reviewer 5:
The reviewer believed that the proposed tasks for the remainder of FY 2015 are appropriate to complete the benchmarking of traction systems of interest. This person was encouraged to see the addition of chargers to the teardown as this may have a larger impact on the creation or updating of standards. The reviewer concluded that the continued use of and improvement of the standard benchmarking is great.

Reviewer 6:
The reviewer said that future research seemed appropriate, but would have liked more time spent on the dissemination of data in a more transparent of graphical manner to better reveal the state of the art and its trends.

Reviewer 7:
The reviewer stated that the team may perform more technical tests on each component, though it may require more resources.

Question 4: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer praised that collaboration among the laboratories is outstanding. The information shared among the laboratories is an example of using the best resource for the task at hand with Argonne National Laboratory (ANL) providing vehicle performance data to ORNL to enable operating conditions to be set and ORNL providing component data to ANL for use in AUTONOMIE for more accurate simulations. AMES is the appropriate source for magnetic characterization. The reviewer concluded that this project may be used as the prime example of team collaboration.

Reviewer 2:
The reviewer found that the current degree of collaboration is appropriate for this topic.

Reviewer 3:
The reviewer commented the team has involved all the technical resources required to complete the project.

Reviewer 4:

The reviewer observed that most of the effort seems to be taking place within Oak Ridge National Laboratory (ORNL), which is okay because a good system and process have been established over the years.

Reviewer 5:

The reviewer said that the group works with several national laboratories and collaborates with John Deere on benchmarking areas. Additional industry partners could hasten the benchmarking process, though the reviewer realized this would come with many challenges (and perhaps has already been pursued).

Reviewer 6:

The reviewer said that it would be nice to see U.S.-based Tier 1 involvement for benchmarking, for instance, Magna Powertrain, Delphi, etc.

Reviewer 7:

The reviewer noted that although collaborator bullet items were included in the presentation, the level of participation from collaborators was unclear.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer concluded that the project benchmarks the performance of highly relevant international efforts in the electric vehicle (EV) and HEV areas.

Reviewer 2:

The reviewer thought the project was very relevant and effective in identifying the state-of-the art and comparing it to the DOE targets.

Reviewer 3:

This reviewer reported that the project helps Tier 1 and Tier 2 suppliers understand details of system architecture, system performance, for future improvement of vehicles.

Reviewer 4:

The reviewer’s assessment was that this work provides electric drive developers with hard technical targets for their respective systems. This hastens development cycles, allows smooth integration with existing and emerging systems, and eases the challenge of bringing energy efficient technologies to market.

Reviewer 5:

The reviewer believed that this project provides the critical benchmark information for other projects under the Vehicle Technologies Office (VTO).

Reviewer 6:

The reviewer considered benchmarking to be important to understand to state of the art production design and identify the gap for the future DOE target.

Reviewer 7:

This reviewer reported that this function is providing the status of the electric drive traction systems used in current production vehicles. This provides useable information regarding the remaining barriers and technology areas that require additional emphasis. This information can be used to identify research areas as well as prioritize them. Additionally, the reviewer stated that this task enables informal communication between industry and DOE regarding the goals and objectives of their programs.

Reviewer 8:

This reviewer thought that it does support goals, but indirectly, by providing a baseline for future innovations.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer maintained that the results indicate that the task has sufficient resources in most cases as the reports are provided in a reasonable time – per the timeline. The reviewer inquired if the timeline was adequate and can more resources to support it could be justified. In general, the reviewer thought that the resources are okay, but having access to additional resources when required to support the typical issues may be justified. Based on the presentation, additional resources for assisting with the integration of the drive unit to the ORNL dynamometer and the control software may speed the evaluation up enough to allow faster reporting.

Reviewer 2:

The reviewer thought the resources were sufficient based on the level of effort.

Reviewer 3:

This reviewer agreed that the team had all the resources required to complete the project on a timely fashion.

Reviewer 4:

The resources seemed sufficient to this reviewer.

Reviewer 5:

The reviewer reported that this project appeared to have sufficient resources.

Reviewer 6:

The reviewer thought the scale of the effort appeared to be correct.

DREAM (Development of Radically Enhanced Alnico Magnets): Iver Anderson (Ames National Laboratory) - edt015

Presenter

Iver Anderson, Ames National Laboratory.

Reviewer Sample Size

A total of six reviewers evaluated this project.

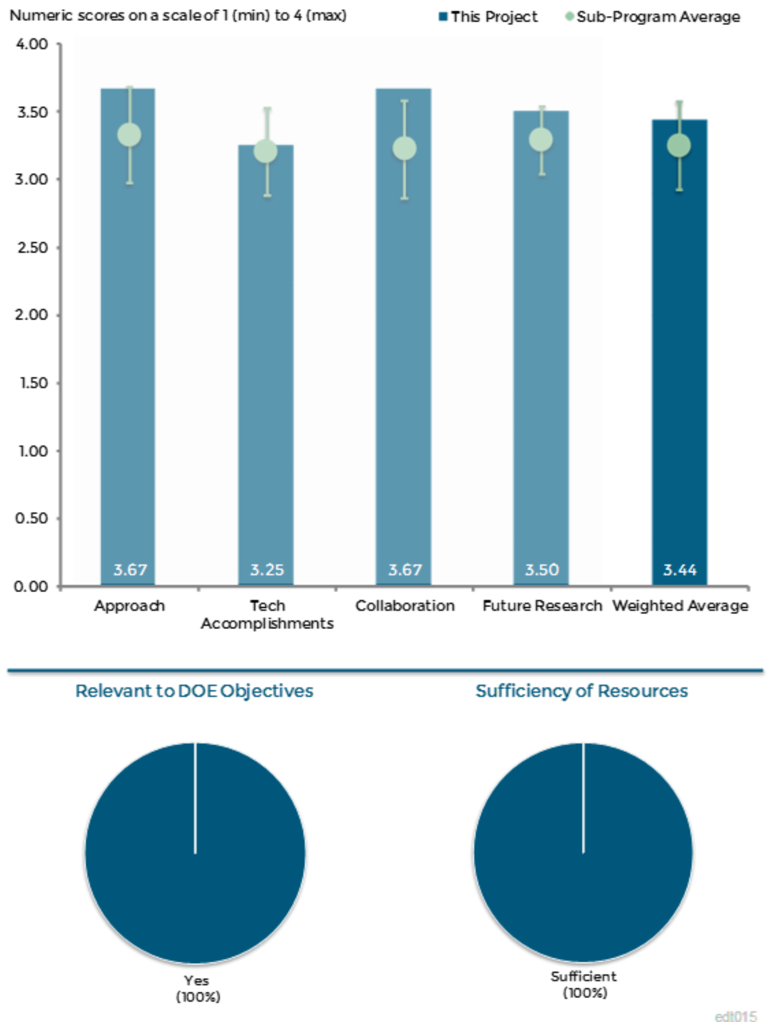

Figure 3-2 DREAM (Development of Radically Enhanced Alnico Magnets): Iver Anderson (Ames National Laboratory) - Electric Drive Technologies

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer reported that the project had great understanding at microstructure level by applying theory and experiment methods.

Reviewer 2:

The reviewer was excited to see if the team could achieve the very clear high level goals associated with an eventual motor application in this project. How these goals are translated to the specific activities within the program on magnet development appeared somewhat nebulous. The reviewer requested clarification on whether the current barrier to using aluminum/nickel/cobalt (AlNiCo) magnets is the Co content or the significantly lower energy density, and coercivity. The reviewer thought that it would be good to see a clear set of target metrics for this program, set prior to the go/no go decision point, and asked if the team can work with UQM to flowdown the minimum set of magnet properties needed for competitive performance compared to integrated permanent magnet (IPM) motors with rare earth (RE) permanent magnets (PM). General Electric (GE) appears to think even with the improved energy density, the motors do not compare well. This reviewer would be interested to see what advantages the current strengths of AlNiCo (e.g., very high temperature stability) provides to motors and assess if those aspects of the magnet properties should be focused on.

Reviewer 3:

The reviewer found the technical barriers to be quite well defined, and theoretical foundations to be sound, but that there seemed to be some lack of integration with other efforts, in terms of coordinating with absolute end users (e.g., automotive and aerospace industry), who could potentially benefit from the technology.

Reviewer 4:

The reviewer thought that the technical quality of the work is great, but that communicating a clear plan was not done well. The overall message of AlNiCo being viable was delivered, but sheer number of variables and options presented was excessive. The reviewer understood it is some basic research, but advised defining the AlNiCo research space/map and the multivariable thrusts being pursued to achieve performance boosts with more transparency. The reviewer counseled the project team spend more time laying out the map before getting into the weeds, so to speak.

Reviewer 5:

The reviewer determined the project had a very detailed approach to addressing the technical challenges, measurements, and processes to understand the metallurgical ways to improve the capability of AlNiCo magnets. There are several identified improvements in processing and chemistry to improve the magnetic properties of the AlNiCo 8 magnets. The reviewer suggested that integrating the improvements into a net capability be tracked. The reviewer found it hard to understand the overall progress from the briefing.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer saw great efforts in improving coercivity of the AlNiCo magnet material. The coercivity of the AlNiCo magnet need to be improved to at least 4,500 Oersteds (Oe) at 150°C for it to be considered as a viable option in designing PM motors.

Reviewer 2:

The reviewer reported that work is about 19% complete, which is compatible with the total time span of the project. Although the desired focus at each year end has been indicated, this reviewer thought that a comparison chart or bar graph showing the desired milestone versus accomplishment would have been better to understand the status.

Reviewer 3:

The reviewer reduced the grade given this project because the progress towards the DOE goals is not being tracked as an aggregate. During the briefing, a target of 20 megaGauss Oersteds (MGOe) was mentioned. The reviewer suggested that this long term target or goal be captured and then broken down to define targets for each of the areas that have been, or are being studied. The reviewer provided the following path as a notional example, showing the path to 20, and proposed that it would look better on a graph MGOe on the vertical and time or other on the horizontal axis: starting point for AlNiCo 8 at 10 MGOe; MA anneal temperature for optimization of coercive field strength (HcJ) (Oe) from 800 to 1360 equal to 20% at 10.5 MGOe; drawing impact 1360-1845 equal to 26% at 11 MGOe; alloying optimization at 12; titanium optimization at 13; prolonged sintering at 14; copper precipitation at 15; magnetic annealing time optimization at 16; and undiscovered improvement required to get to 20 (super AlNiCo/other).

Reviewer 4:

The reviewer reported that the bulk of the work so far appeared to be on the reduction of cobalt, but that it was not clear what ideas were being pursued to improve the coercivity significantly beyond current state-of-the-art. The reviewer asked if it was the expectation of the team that the reduced cobalt content combined with improved processing to obtain better nanostructure will lead to the higher coercivity and energy density of 20 MGOe. Based on progress so far, the path to the higher energy density target is not clear to this reviewer.

Reviewer 5:

The reviewer saw lots of good work on the materials science end; however, the specific impact of each potential advancement in the material science should be summarized or at least attempted. This person advised that quantifying improvements towards the end goal.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer reported that many different organizations are referenced as contributing and the slides clearly provide credit where they are leading/contributing.

Reviewer 2:

The reviewer judged collaboration with the industrial partners and national laboratories to be adequate.

Reviewer 3:

The reviewer thought collaboration and coordination with various institutions (i.e., academia and industry), was excellent. This person advised that it would add more benefit if some coordination was also done with end users of the final product; automotive, aerospace, and other industries who use electric motors in a complete system.

Reviewer 4:

The reviewer deemed the collaboration with the motor developer that is working on an AlNiCo-based motor to be very strategic. This person proposed that the team consider tighter collaboration to perform trade-off studies on the different magnet properties – coercivity, energy density, high temperature performance, and mechanical properties – to establish the sweet spot for AlNiCo. It will also be good to have discussions with GE, the other team that has worked on AlNiCo motors, to reconcile any difference in opinion.

Reviewer 5:

Although collaborations are listed, this reviewer was not entirely sure how strong some of them were.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer concluded that the project is well planned, but listed a few additional issues which would add benefit: first, 15 years' lifetime has been indicated for the magnets. It may be important also to think ahead about how to recycle those materials at the end of the lifetime; second, although comparison with different versions of the AlNiCo has been emphasized, a clear comparison between AlNiCo material developed in this project against RE materials also should be indicated more clearly, since after all, the intention is to replace the RE material. It has been indicated that the Go/No Go decision was based on a comparison between bulk sub-sized AlNiCo magnets against AlNiCo 8HE or 9. This comparison should be extended to RE magnets as well to better understand the complete picture; third, manufacturing process for high volume production should also be thought ahead, because eventually that will be necessary; and fourth, more detailed references on existing work such as patents and papers would be helpful.

Reviewer 2:

This reviewer would recommend slightly modifying the goal of the project from improving magnetic properties compared to AlNiCo 8HE and AlNiCo 9, to establishing minimum thresholds beyond which the material become a viable alternative to RE PM and trying to meet those. This may include a combination of trying to make up for the shortcomings of the material relative to RE magnets, and further improving on its strengths.

Reviewer 3:

The proposed future work will be very useful for advancing PM technology, but the reviewer would appreciate more quantification of the potential contributions of specific thrusts going forward.

Reviewer 4:
The reviewer would like to see the game plan that leads to 20 MGOe. Although the future work is good and great progress is being made, this reviewer would just like to see how the project team would get to the end goal.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer submitted that a viable non-RE PM alternative would help in the penetration of electric or hybrid vehicles, which can lead to petroleum displacement.

Reviewer 2:
The reviewer believed that this work will make electric motors much more accessible for vehicle drive applications.

Reviewer 3:
Considering the volatility in price of the heavy RE material, this reviewer found that alternate options such AlNiCo provide cost effective solutions for the electric propulsion systems.

Reviewer 4:
The reviewer indicated that AlNiCo magnet manufacturing is capable of integrating the process and chemistry changes, so when the right solution is found, the time to get to the commercialized solution is short. The reviewer thought the cost of the vastly improved AlNiCo 8 magnets should be extremely competitive against rare-earth magnets, and not dependent on supply from China.

Reviewer 5:
This reviewer explained that in the mid- to long-term run it does, even though immediately it may not; because the project is about replacement of the existing motors which use RE materials, thus petroleum displacement may come about indirectly. If petroleum displacement in terms of vehicular fuel economy is considered, then it will not displace petroleum consumption. However, if the cost of getting RE material and its manufacturing process involve petroleum, then it may save fuel in an indirect manner.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer saw that lots of great progress is being made, and asked the project team to please keep the focus on getting to 20 MGOe.

Reviewer 2:
The reviewer appraised the resources to be sufficient.

Reviewer 3:
The reviewer’s assessment was that the resources indicated were reasonable.

North American Electric Traction Drive Supply Chain Analysis: Focus on Motors: Christopher Whaling (Synthesis Partners) - edt032

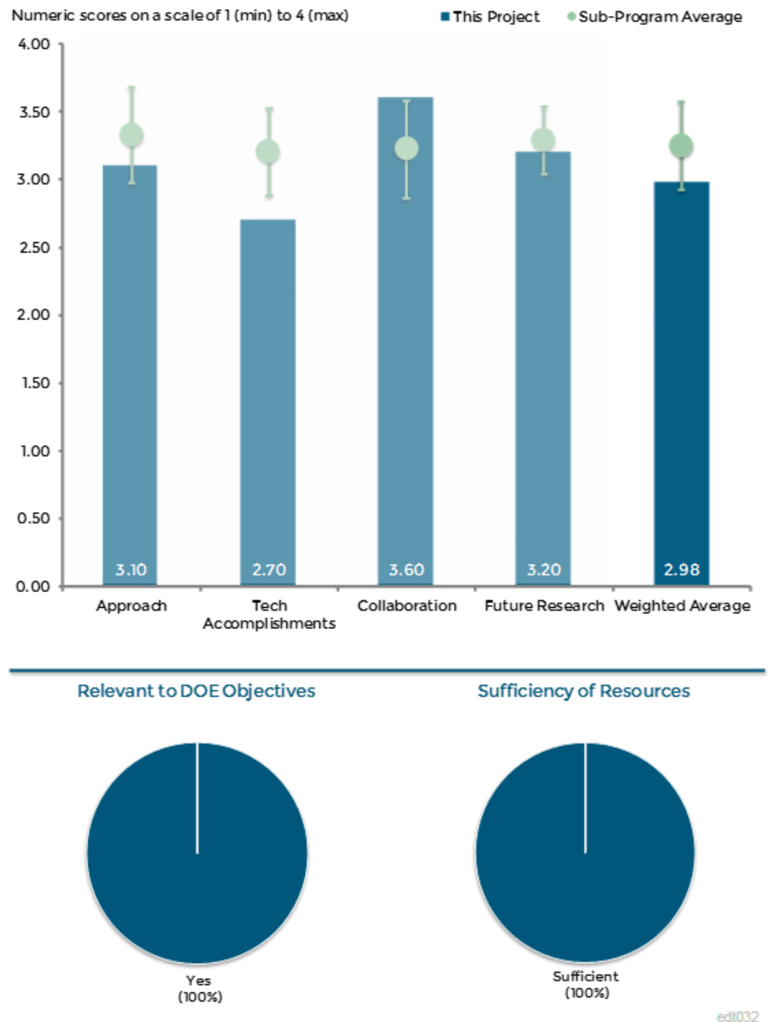

Figure 3-3 North American Electric Traction Drive Supply Chain Analysis: Focus on Motors: Christopher Whaling (Synthesis Partners) - Electric Drive Technologies

Presenter

Christopher Whaling, Synthesis Partners.

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer reported that the project appears to be well directed to assess the business state of North American EV efforts. Because results are preliminary and summarized at a very high level in the slides, they were difficult for this reviewer to assess at this intermediate point.

Reviewer 2:

The reviewer found good diversified approach in terms of the entities reached out to for interviews and information, but would have liked to see more in-depth interviews as well as a more expansive literature survey.

Reviewer 3:

The reviewer reported that the approach chosen was to collect, analyze, and report on data related to specific questions from DOE VTO, and concluded that this is a difficult task as the team needs to have a relationship with the suppliers based on trust to get any meaningful data. This person reflected that so far this has worked for this team on past surveys. Past presentations from this team have focused on inverters and related technology or components while this one focuses on motors. The reviewer liked the initial conclusions; even though they were preliminary, they still gave a sense of direction or status of current industry trends. The approach outlined on Slide 6 is well suited for this project.

Reviewer 4:

The reviewer thought that the study needed to be more comprehensive and provide actionable items.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer considered these some illuminating preliminary statements of results.

Reviewer 2:

The reviewer thought that the number of in-depth interviews was reasonable for the timeframe reported. The reviewer said that it was nice to see preliminary conclusions understanding that they are preliminary, but that the results are too preliminary to judge progress related to motors. Based on prior project reviews, the project is about where this reviewer expected it to be.

Reviewer 3:

The reviewer reported some good high level observations about the market as well as some good information about the global markets, but suggested a more in depth understanding of the trends and needs of the North America market motors supply chain, and a better understanding of manufacturing cost breakdown, are both needed.

Reviewer 4:

The reviewer expressed that progress needed to be quicker for the information to be of use, and result in clear, actionable items that DOE can act on.

Reviewer 5:

The reviewer was of the opinion that more information was really needed, beyond the current calendar year (CY) 2010-2014 graphs and pie charts. There were a few leaders that stand out (i.e., Toyota, Tesla, BMW, and Nissan, etc.) that are leading the effort on EVs. While they are guarded with their information, it was not clear to this reviewer how the OEM and Tier 1 supply chain plans on addressing the carbon dioxide (CO_2) emission restrictions by market: in the U.S. market, corporate average fuel economy (CAFE) standards require 54 miles per gallon (mpg) by 2025, which most OEMs say is impossible without electrification; in the Chinese market, second largest, the requirement is 60 mpg by 2025; and in the European Union (EU) market, third largest, CO_2 restrictions by 2025.

It would seem to this reviewer that by 2018, automotive OEMs have to have a serious plan to address this pending challenge, or fight government regulators in their top three markets. Tesla and BMW seem poised to illustrate that the technology is there to hit these goals. The reviewer concluded that most of the market information appears to be looking backwards, where the top three market CO_2 restrictions really have not had any bearing. Going forward, especially from 2018 onward, it seemed to this reviewer that this will be the key area of importance to judge EV adoption as the OEMs and government regulators are on a collision course.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer posited that the fact that there is data at all indicates that it is working well, because this project is based on collaboration. The reviewer believed that as the project team continues to build trust within the industry the results will continue.

Reviewer 2:

The reviewer ventured that the ability to establish a diversified network of experts for outreach is good, and that expanding this network can be even more effective.

Reviewer 3:

This reviewer wondered if, while OEMs are more guarded, it would seem Tier 1 suppliers would be more open.

Reviewer 4:
The reviewer reported that 100 research contacts were made, and 20 in-depth interviews contacted in the first quarter of 2015.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
This reviewer believed that continuing to reach out to experts is good, but even more important is vetting the findings so far.

Reviewer 2:
The reviewer determined that future plans are appropriate for this project, because the need to increase the data resource pool is key to a continued source of relevant information, which in turn will enable meaningful conclusions to be drawn, from which direction can be created. The reviewer agreed that getting involvement from the Electrical and Electronics Technical Team (EETT) is desirable.

Reviewer 3:
The reviewer reported that there was no slide on this, but assumed the work will continue in the same direction, and that more details will be presented in a report.

Reviewer 4:
This reviewer referred to previously mentioned ideas for future research.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer postulated that EV adoption is key to reduce petroleum, and market information is needed to tell us when that will happen and what the market drivers will be. The reviewer wondered if this is the main market driver carbon dioxide (CO_2) restrictions.

Reviewer 2:
The reviewer believed that understanding the gaps in North America motors supply chain, and especially targeting traction motors, is very critical to being able to cut cost and establish a reliable North American supply chain for the HEV/EV space.

Reviewer 3:
The reviewer reported that this work assesses the reality and state of the North American business climate in plug-in/hybrid/electric vehicle (xEV) traction drives. The results are important to help guide the nation towards practical achievement of petroleum displacement through EV means.

Reviewer 4:
The reviewer stated that this project provides clear insight into what will make the program successful or not.

Reviewer 5:
The reviewer said that this project provides data that allows the capability of U.S. manufacturing to be determined, which will help determine what additional resources and projects will be needed to meet the DOE goals for US manufacturing of PHEVs.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer thought the allocated resources were sufficient for the level of effort.

Reviewer 2:
The reviewer saw that funding appeared reasonable.

Reviewer 3:
Resources seemed to be sufficient to this reviewer, but was not sure if more would be better or if it would create trust issues.

Next-Generation Inverter: Zilai Zhao (General Motors) - edt040

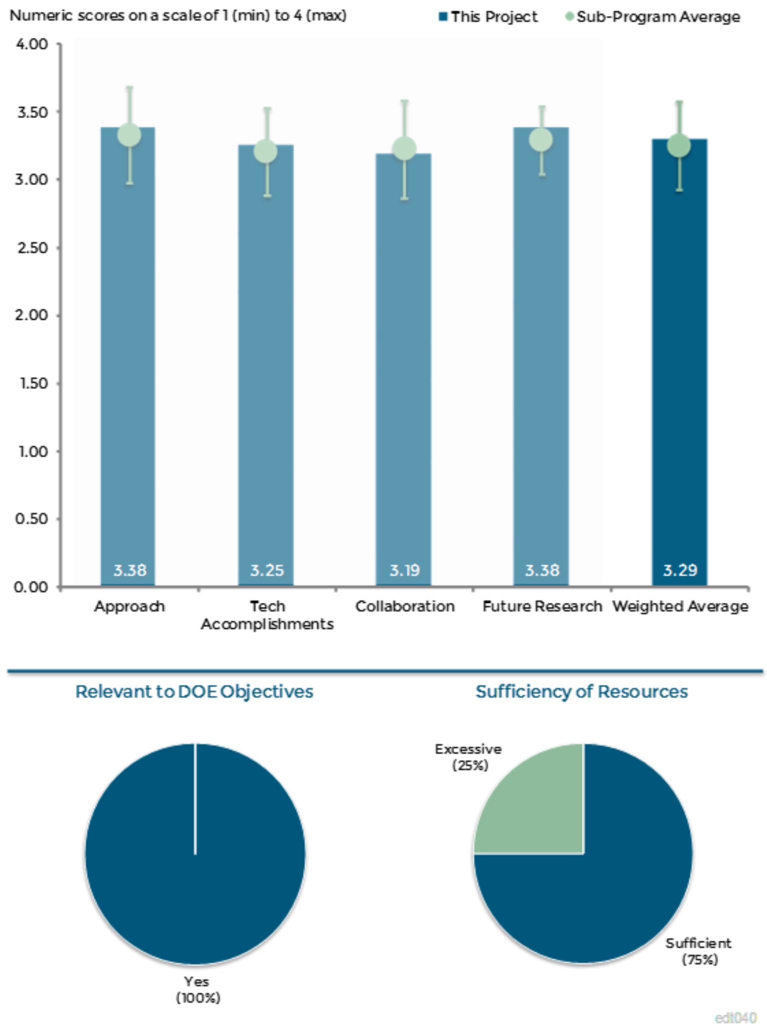

Figure 3-4 Next-Generation Inverter: Zilai Zhao (General Motors) - Electric Drive Technologies

Presenter

Zilai Zhao, General Motors.

Reviewer Sample Size

A total of eight reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer found that developing a concept or reference design to use as a baseline and have others evaluate it was a good approach, and allows for all parties to understand the tradeoffs and limitations of the design.

Reviewer 2:

This reviewer was generally supportive of this effort. The work being done is generally meso- and macro-scale packaging, which the reviewer considered an important near-term development topic that a company such as GM needs to pursue to address cost barriers. The reviewer regretted that few details were given in this presentation, but at least some of the results are given.

Reviewer 3:

The reviewer concluded that the program goals are consistent with the DOE overall goals. However, this person wondered what the temperature requirements for the inverter are in this project, because it was not clear from the objectives or presentation. Also, the reviewer asked if this design is using current silicon (Si) device technology, and if so, how the timeline and output of the project fits with other DOE wide bandgap (WBG) inverter projects that are also ongoing.

Reviewer 4:

The reviewer stated that this project develops technologies and product design for low-cost high efficiency inverter capable of 30kW continuous and 55kW peak power. How cost and performance targets are met is missing from the report and presentation made during AMR.

Reviewer 5:

This reviewer reported that the technical approach was not evident in the presentation or material; however, it appeared that the key technical barriers were getting attention. The reviewer was not clear on what the path is/was.

Reviewer 6:
It was not very clear to the reviewer how the cost reduction can be achieved.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:
The reviewer reported that the project has made progress on size and weight reduction, though there has been delay in milestones.

Reviewer 2:
This reviewer believed that the delay in the estimation of cost should be addressed. Specifically, it would be good to have a rolling estimate that can be updated and shared periodically. The presenter mentioned that the reduced cost is the primary benefit of this design given the same power density as current GM products; however, it was difficult for the reviewer to judge this cost merit without a firm estimate. Additionally, the reliability of the design was not fully clarified. In this reviewer's opinion, low cost is equally as important as high reliability.

Reviewer 3:
The reviewer reported that critical design review had been completed. Inductance of critical semiconductor/capacitor loop was reduced, although this person thought that others have solutions that are better. Substantial thought has been put into the overall assembly process, which the reviewer expected to reduce cost.

Reviewer 4:
The reviewer conveyed that the presentation covered numerous options for manufacturing processed development evaluated resulting in identification of refined manufacturing process, which is stated in the project report submitted for AMR 2015. Vertically integrated processes minimized loop inductance resulting is lower voltage overshoot during power semiconductor turn-off. Direct bonded copper (DBC) direct attach to the inverter cooling system resulting elimination of several thermal layers, hence reduction in the thermal resistance from junction to cooling systems. Integrated concept for the power stage is developed. The reviewer saw that details of electromagnetic interference (EMI) and electromagnetic compatibility (EMC) management method are missing. The reviewer recommended that peak load testing under extreme operating conditions should be evaluated, and that life and reliability of the inverter should be evaluated and determined.

Reviewer 5:
The reviewer sees the focus on manufacturing to reduce cost as a good sign. This person noticed that press-fit pins are being used and although the presenter commented on the pins there were not any comments about the sockets the pins interface with respect to the capacitors. The reviewer asked the project team to comment on the test plan used to evaluate the inverter.

Reviewer 6:
The reviewer observed that progress has been made in a few key areas, such as assembly process and loop inductance, but that it seemed that one of the keys to this configuration is attachment of DBC. This person was not sure this is adequately resolved yet, and was also a little disappointed in the delay of one year to provide production cost estimation.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer remarked on the very strong, balanced team from the United States, Japan, and European Union.

Reviewer 2:
The reviewer observed a great team assembled under this project and thought that the OEM, several key Tier 1, 2, and 3 suppliers, and the key power electronics national laboratories were a fabulous slice through the industries. However, the actual contributions or involvement was unclear. The reviewer would like to know a little about what role the project team members play or how active the participation is for each.

Reviewer 3:
This reviewer stated that GM is working with a substantial number of suppliers and partners, as one would expect.

Reviewer 4:
The reviewer reported that ORNL and the National Renewable Energy Laboratory (NREL) are stated as collaborators

Reviewer 5:
The reviewer stated that there were many partners and collaborators.

Reviewer 6:
The reviewer believed the project had the power to collaborate with the entire supply chain.

Reviewer 7:
The reviewer thought the role of the collaboration partners was not clear at all from the presentation.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer was definitely looking forward to the future evolution of this inverter, including the evaluation of WBG semiconductors, even if this will be done outside this program.

Reviewer 2:
The reviewer observed that key tasks are identified and are targeted towards relevant future activities in the project.

Reviewer 3:
The reviewer saw that they have a plan.

Reviewer 4:
The reviewer said that the remainder of 2015 work appears to be appropriate to the project. Again, it was difficult for this person to evaluate because of the limited data shown.

Reviewer 5:
The reviewer declared the team presented organized and logical next steps; now, just execute them.

Reviewer 6:
The reviewer referenced previously discussed cost and reliability assessment comments, and maintained that an initial cost and reliability assessment relative to the DOE targets would be beneficial to understand the potential benefit of this technology. In terms of extending this technology to WBG devices, there seemed to this person to be some challenges that would be imparted by the existing design. The reviewer asked how addressing these challenges would disrupt the overall architecture of the inverter.

Reviewer 7:
The reviewer opined that the project might have provided more information on the cost reduction target.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer declared that moving advanced inverter technologies into production is a key benefit of the DOE activity, and this project supports that goal.

Reviewer 2:
Development of GM xEV technology could make a substantial and direct impact on petroleum consumption in the United States.

Reviewer 3:
The reviewer resolved that lowering the cost of electric-drive vehicles (EDV) power electronics helps to enable the market for EDV's which reduces our dependence on foreign oil.

Reviewer 4:
The reviewer thought that project work could meet DOE Advanced Power Electronics and Electric Motors (APEEM) targets, resulting in penetration and adoption of the power electronics into EVs everywhere.

Reviewer 5:
The reviewer said that cheaper and possibly more efficient power electronics are required for acceptance, and this project is written for just that.

Reviewer 6:
The reviewer pointed out that the project has been working on next generation vehicle power inverters with reduced size and weight.

Reviewer 7:
The reviewer related that a traction inverter is a key module in the xEV electrified power train system.

Reviewer 8:
The reviewer reported that the project took a ground-up look at a completely new inverter, valuing power density, efficiency, and ease of manufacturing steps. This person saw very thorough work in lowering the cost of this critical portion of EV drivetrains, and thought that future work evaluating WBG semiconductor and other packaging techniques will be important, even if done outside this program.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer was very impressed with the amount of industry involvement from cost-share.

Reviewer 2:
Given the limited details presented, it was difficult for this reviewer to assess the value of the results relative to the DOE funds expended. On the other hand, two-thirds of the funds are GM cost share, and efforts in this area by GM are to be encouraged.

Reviewer 3:
The reviewer pointed out that the team is the largest automotive manufacturer.

Reviewer 4:
The reviewer thought that resources seemed sufficient in terms of the project cost, but hard to tell if it is resourced adequately at GM and the subs based upon the progress so far. It seemed to this person that this project is almost over yet there is still lots more work to do.

Unique Lanthide-Free Motor Construction: Alan Gilbert (UQM Technologies, Inc.) - edt044

Presenter

Josh Ley, UQM Technologies, Inc.

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

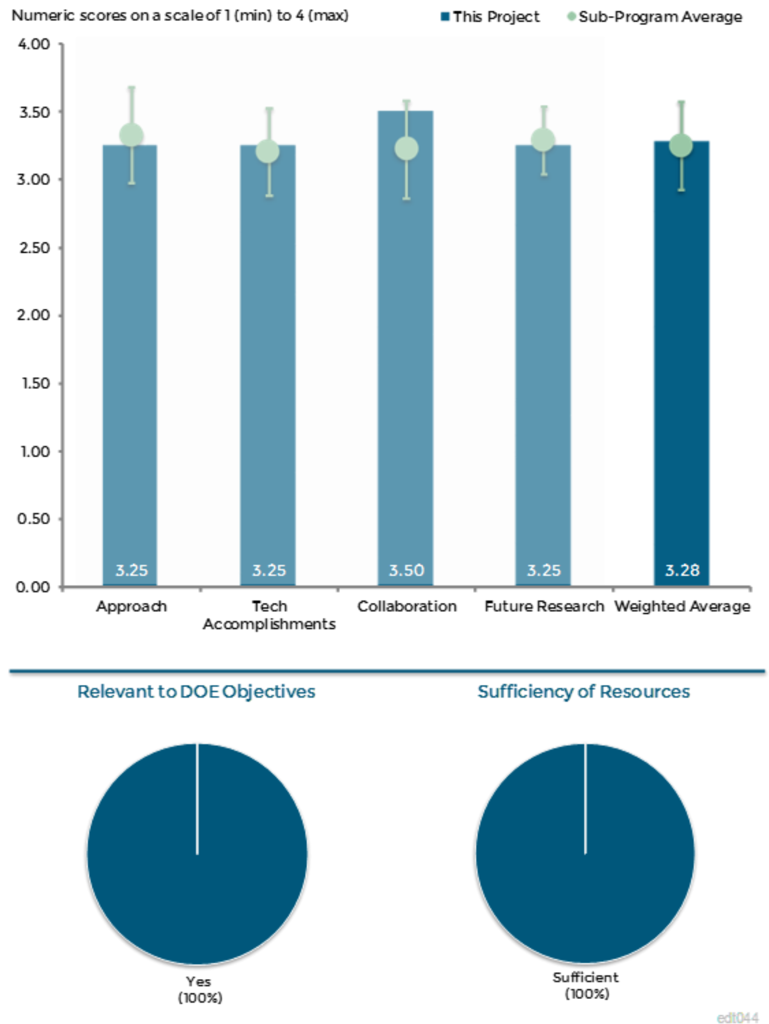

Figure 3-5 Unique Lanthide-Free Motor Construction: Alan Gilbert (UQM Technologies, Inc.) - Electric Drive Technologies

Reviewer 1:

The reviewer thought that the technical barriers are well defined in general. Integration with other efforts have been indicated explicitly in terms of automotive industry applications, which could potentially benefit from the technology.

Reviewer 2:

The reviewer declared that given the results achieved to date, the project is on an excellent path. However, further project progress is dependent on Ames Laboratory (AMES) delivering improved AlNiCo 8 magnets to improve the motor’s top speed and torque capability. If the magnetic material is challenged for arrival, the project will suffer significantly. This reviewer emphatically praised Ames.

The reviewer went on to say, regarding the technology, that the surface mounting scheme that does not require much or any back iron is ideal for integrated starter motor generators (ISMGs) for parallel hybrid systems. The relative hollowness of the design enables packaging of the rotor around torque converters and clutches, or other components. This reviewer found that the challenge to address this market is to get the coolant temperature requirement closer to the 105°C capability, and suggested that a next phase for the project to work on increasing the temperature rating.

Reviewer 3:

The reviewer determined that, while the overall goals of the program are sound, the technical requirements for the motor appear to be too light relative to the many interrelated constraints being addressed by other teams, including elevated coolant temperature, tight system costs, etc. The reviewer stated that the summary statement by the team that the POC motor demonstrates performance very close to requirements with OTS magnet material may be accurate for the narrowly defined specs, but given the relaxed specifications (e.g., coolant temperature and transient conditions the motor needs to ride through), there may be room for improvement. It appeared to this person that for the AlNiCo properties available, the motor is just barely able to operate at steady state conditions, and it was not clear it can survive fault conditions without significant demagnetization. The reviewer recommended that the team should discuss with DOE or NREL to obtain reasonable specs on transient performance.

Reviewer 4:

The reviewer believed that the key to using AlNiCo is in how to design rotor structure, but conveyed that the presentation did not talk about it at all for the reviewer to adequately rate the design and its success in the real world.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer declared that the technical accomplishments for the first generation are excellent - a scorecard was provided, which was helpful. However, the reviewer pointed out that the first DOE requirement of greater than 90% efficiency was only reported as Analyzed, Comply, and that all other key DOE requirements had some discussion and data. This person suggested that an efficiency map be added or provided that shows efficiency as a function of speed and power or speed and torque.

The reviewer went on to say that NREL has the contract scope element of cost, but there was no data provided that discusses the design impact on overall cost. The person suggested that cost be a key element to be discussed. Mentioned within the briefing was that the current design magnetic material is not reduced due to the volume. Again, the reviewer indicated that the AMES project has the potential to significantly impact by providing a more power dense low cost magnet.

Reviewer 2:

The reviewer reported that work is about 80% complete, which is compatible with the total time span of the project. Although desired focus at each year end has been indicated clearly on items so far completed, from November 2014 until now, the accomplishment has not been clearly mentioned.

Reviewer 3:

The reviewer was of the opinion that the experiment results shared of POC one and two were marginally meeting the set goals by DOE. More details on the experiment results will be great to evaluate the design and its performance for the next time.

Reviewer 4:

The reviewer thought the design appeared to be at the hairy edge of demagnetization even under steady state load, the effect of armature reaction could be significantly higher under fault conditions (e.g., terminal short circuits), and needs to be studied rigorously.

This reviewer reported that the rotor design was not discussed in detail, but verbal comments suggested it is mostly air-core with the magnetic flux primarily going through the permanent magnets themselves. One would expect this to result in low armature reactance fields, but also very low reactances, on the order of 0.1 per unit (p.u.), and high short circuit currents, which would magnify the above problems. The reviewer asked the project team to please analyze this in detail.

Also, the reviewer pointed out that while the approach eliminates RE PM and may mitigate RE availability risks, it is not clear that the current design, with three times the amount of magnets, is a viable commercial alternative.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer stated that all partners have clearly defined roles and contribute well to the overall value of the project.

Reviewer 2:
The reviewer sensed that the team is leveraging capability at the national laboratories very well, but suggested that there may be opportunity to reach out to other organizations to study impact of a more comprehensive set of specifications, including the potential for magnet demagnetization under fault conditions.

Reviewer 3:
The reviewer saw that collaboration and coordination with various institutions are only with government laboratories, and that there seemed to be lack of collaboration with academia and other industry. This person thought that it would add more benefit if some coordination was also done with end users of the final product such as automotive, aerospace, and other industries who use electric motors in a complete system.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer related that future work has been clearly indicated, but suggested a few additional issues which will add benefit. First, comparison between AlNiCo materials developed in this project against RE materials also should be indicated more clearly, because after all, the intention is to replace the RE material. Second, manufacturing process for high volume production should also be thought ahead, because eventually that will be necessary. Third, the cost issue has not been clearly indicated. Finally, more detailed references such as patents and papers on existing work would be helpful.

Reviewer 2:
The reviewer said that because the impact of inferior permanent magnet properties is one of the largest risks, the plan laid out would make the most sense if representative magnets are utilized in the motor construction. This reviewer recommended the team wait for improved AlNiCo to perform a more relevant demonstration.

Reviewer 3:
The reviewer concluded that the critical barrier for the project is for AMES to deliver the 30% (or more) improved AlNiCo 8 magnetic material capable of integration into a motor. Based on review of AMES project edt015, it seemed very likely to this reviewer that the improved magnetic material will be provided.

Reviewer 4:
The reviewer recommended that future work should also include direct comparison of equivalent AlNiCo and NdFeB PM motors for performance, cost and manufacturability.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer concluded that the project addresses the DOE goals of elimination of RE magnets, power density, and efficiency. An element that needs to be discussed further is how the project contributes to cost reduction.

Reviewer 2:
The reviewer thought that, considering the volatility in price of the heavy RE material, alternate option such AlNiCo provides cost effective solution for the electric propulsion systems.

Reviewer 3:

The reviewer determined that a motor that meets DOE requirements with AlNiCo magnets would mitigate the RE PM supply risks

Reviewer 4:

The reviewer thought that this project contributes indirectly, and in the mid- to long-term run it does. It may not directly influence the petroleum displacement, because it is about replacement of the existing motors which use rare earth materials. If petroleum displacement in terms of vehicular fuel economy is considered then it will not displace petroleum consumption. However, the reviewer deduced that if the cost of getting RE material and its manufacturing process involve petroleum, then it may save fuel in an indirect manner.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that resources indicated were reasonable.

Reviewer 2:

The reviewer believed that based on the funding level, this project is sufficiently funded. Based on discussions during the briefing that John Lutz had passed away, the funding level may need to be revisited if his loss is requiring more than planned resources to be applied, in order to continue at the same rate.

Reviewer 3:

The reviewer said that UQM would be in a good position to determine if the resources are sufficient based on their extensive experience with similar projects.

Alternative High-Performance Motors with Non-Rare Earth Materials: Ayman El-Refaie (General Electric) - edt045

Presenter

Ayman El-Refaie, General Electric.

Reviewer Sample Size

A total of four reviewers evaluated this project.

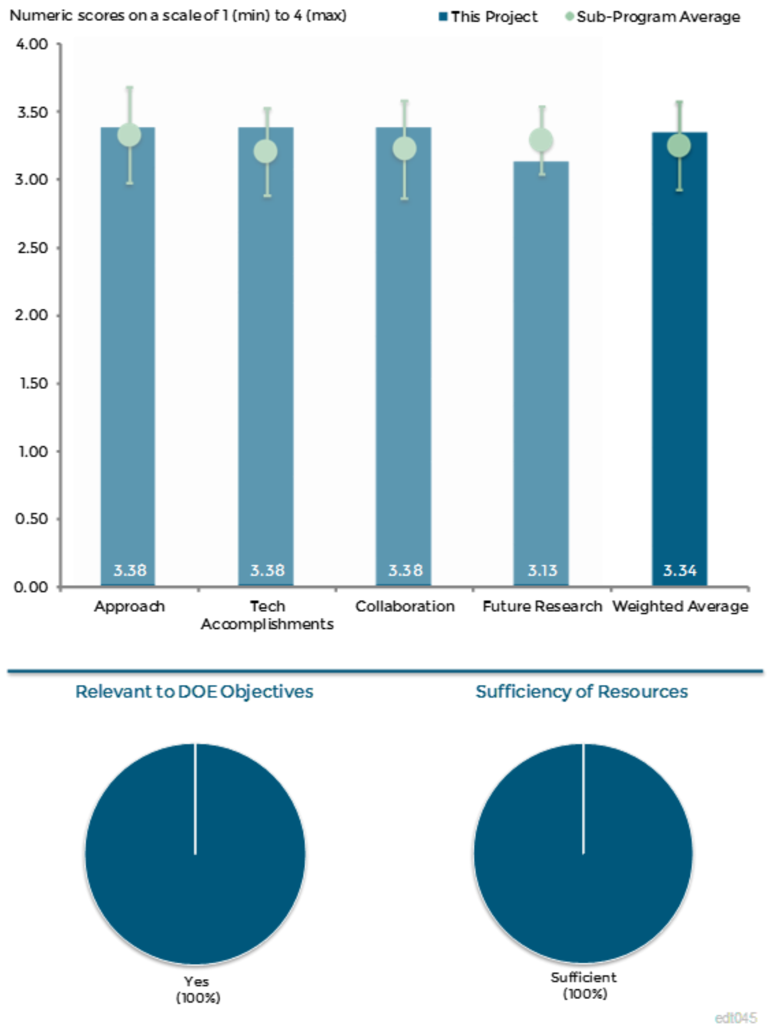

Figure 3-6 Alternative High-Performance Motors with Non-Rare Earth Materials: Ayman El-Refaie (General Electric) - Electric Drive Technologies

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer reported that this team is pursuing a very comprehensive search for machine topologies and enabling technologies to address the rare-earth permanent magnet challenge. While the reviewer thought this may be a good approach if sufficient resources are available, it would help to perform a down selection and focus on ideas with the greatest chance of making significant impact.

The reviewer expected that the team should be able to compare the motors being studied by computer modeling and analysis, because they are extensions of known topologies. There will be uncertainties, but it will be good to select the one or two most promising machine type to proceed to hardware demonstration.

Reviewer 2:

The reviewer judged the technical barriers to be well defined and clearly itemized. Although partnership with other entities have been clearly indicated, integration with other similar efforts or leveraging other existing efforts were not so clear to this person.

Reviewer 3:

The reviewer relayed that GE's approach to performing the work is to evaluate at least 10 different motor topologies that have the potential of meeting the DOE goals for motor performance without the use of RE magnets. Where conventional technology will not support meeting the performance requirement, GE is, in some cases, developing capabilities that make the motor topology possible, such as dual phase magnetic material and higher temperature insulation materials.

The reviewer thought that, where 10 topologies were evaluated, it would have been good to see the breakdown of how the different topologies performed and where they missed meeting the requirements.

Reviewer 4:

It seemed to this reviewer that GE's lack of OEM knowledge for the system optimization of HEV/EV applications may impact their ability to select the best design for such applications. The reviewer recommended that GE allow themselves some flexibility in the requirements, especially max speed and coolant temperature to see if this permits a better and/or cheaper motor design.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer reported that work is 78% complete, which seemed compatible with the total timespan of the project. Each year-end has been indicated clearly on items so far completed.

Reviewer 2:

The reviewer thought the new method for creating locally non-magnetic regions in motor laminations sounds interesting, though it could be quite a challenge to manufacture such laminations in mass production.

Reviewer 3:

It was clear to the reviewer that the team has done a very thorough work on both the motor and material development. However, this reviewer is wondering if the most effective path towards demonstrating the most promising technologies is being pursued.

This person asked for the team to please provide a summary of how the different motors stack-up against each other with an apples-to-apples comparison, with technical risks. While pieces of information were available throughout the presentation, it would help to have a table showing how the machines compare in terms of the key design specs. It was also not clear to this person what major risks were retired by the testing of the ferrite IPM motor. The electromagnetic performance is fairly well predicted with the sophisticated modeling tools available these days.

The reviewer concluded that if the team feels the dual phase material can be the most disruptive technology to come out this effort, it should allocate enough resources to try and scale this up and incorporate in a motor to demonstrate its benefits.

Reviewer 4:

The reviewer said the lack of a scorecard for motor topologies relative to the expressed targets makes it hard to evaluate the progress toward the goal, and recommended that a scorecard be provided for each relevant motor topology to understand how the motor performed relative to the goal. A one-page scorecard would work, and would make it clear why a particular topology was chosen.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer concluded that it was good to see the team pursuing broad collaboration across industry, academia, and national laboratories. This reviewer pointed out that one area for improvement may be collaboration within GE itself. It was not obvious from the presentations how much of this is taking place, but there may be value to finding traction motor applications within GE that have similar requirements as the DOE program and seek synergistic ways in which to demonstrate some of the disruptive non-rare earth (NRE) motor technology being developed.

Reviewer 2:

The reviewer reported that collaboration and coordination with various institutions have been very clearly indicated. It would add more benefit if some coordination was also done with end users other than the institution of the principal investigator (PI), i.e. with end user of the final product e.g., automotive, aerospace, and other industries who use electric motors in a complete system.

Reviewer 3:

The reviewer expressed that the briefing and discussion does not make it clear on how the partners participated. For instance, there are three universities that have a role of evaluation of motor topologies, and it was not clear to the reviewer how the evaluations were completed. This person asked if their role for the evaluations was completed on physical motors, or if this was a modeling study. Further queries were expressed about whether all evaluated the same motors independently, or if the evaluation was completed as an integrated team. The reviewer stated that it is possible that this was a great story to be told but it is not easy to interpret based on the briefing materials and the briefing.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that future work had been clearly indicated. A few additional issues that this reviewer expected will add benefit are as follows: One, manufacturing process for high volume production should also be thought ahead, because eventually that will be necessary. Two, the cost issue has not been very clearly indicated. Three, more detailed references such as patents and papers on existing work will be helpful.

Reviewer 2:

The reviewer reported that proposed work gets down to a final evaluation of motor topologies and choosing a path forward on one or more designs that have a high likelihood of meeting the performance and cost requirements. The scorecard will be a handy tool to provide the team with a clear picture to make the decision. The reviewer suggested that Slide 16, fourth bullet be changed to state finish the design for the final motor(s), because FY 2016 is the build and evaluation of the motors. Another option suggested was that a bullet be added to FY 2016 stating finishing the design before the build and test bullet.

Reviewer 3:

The reviewer realized that although it may not be easy to do at this stage in the program, the team should try to focus the program on the one or two key innovations with the greatest promise of impacting NRE motors. With information available to the team now, the team can try to separate the options that would make incremental advances from those that can be truly game-changing, and focus on those, e.g., the dual phase material for rotor laminations. The reviewer recommended that resources be allocated to do more work to understand the mechanical properties and manufacturing considerations.

Reviewer 4:

This reviewer proposed that when evaluating or selecting the best performing motor option, GE should describe the pros and cons of the inverter topologies for the different motor concepts as this could have an impact on the overall system cost.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer reasoned that having low-cost, high-performance motors that are not dependent on volatile RE permanent magnets will add the stability to product costs that OEM's need. This person pointed out that this project also is developing technologies that are very innovative and could change or increase the options available to motor designers to maximize motor capability.

Reviewer 2:

The reviewer declared that all approaches being worked on have the potential to help reduce reliance on RE permanent magnet materials.

Reviewer 3:

The reviewer related that while this project may not directly influence the petroleum displacement, because it is about replacement of the existing motors which use RE materials. If petroleum displacement in terms of vehicular fuel economy is considered, then it will not displace petroleum consumption. However, this reviewer believed that if the cost of getting RE material and its manufacturing process involve petroleum, then it may save fuel in an indirect manner.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer reported that the funding is approximately $2 million per year, and that there is a lot of motor topology evaluation and materials development. The reviewer considers this to be a good value for the funding available.

Reviewer 2:

This reviewer agreed that this is a well-funded project. However, it appeared to this person that the team is looking in many different directions, and that a better utilization of the resources may be obtained by focusing more narrowly.

Reviewer 3:

The reviewer said that resources indicated are sufficient, but that even though there is 50% cost sharing, possibly the project could be done at a lesser cost.

Advanced Packaging Technologies and Designs: Zhenxian Liang (Oak Ridge National Laboratory) - edt049

Presenter

Zhenxian Liang, Oak Ridge National Laboratory.

Reviewer Sample Size

A total of seven reviewers evaluated this project.

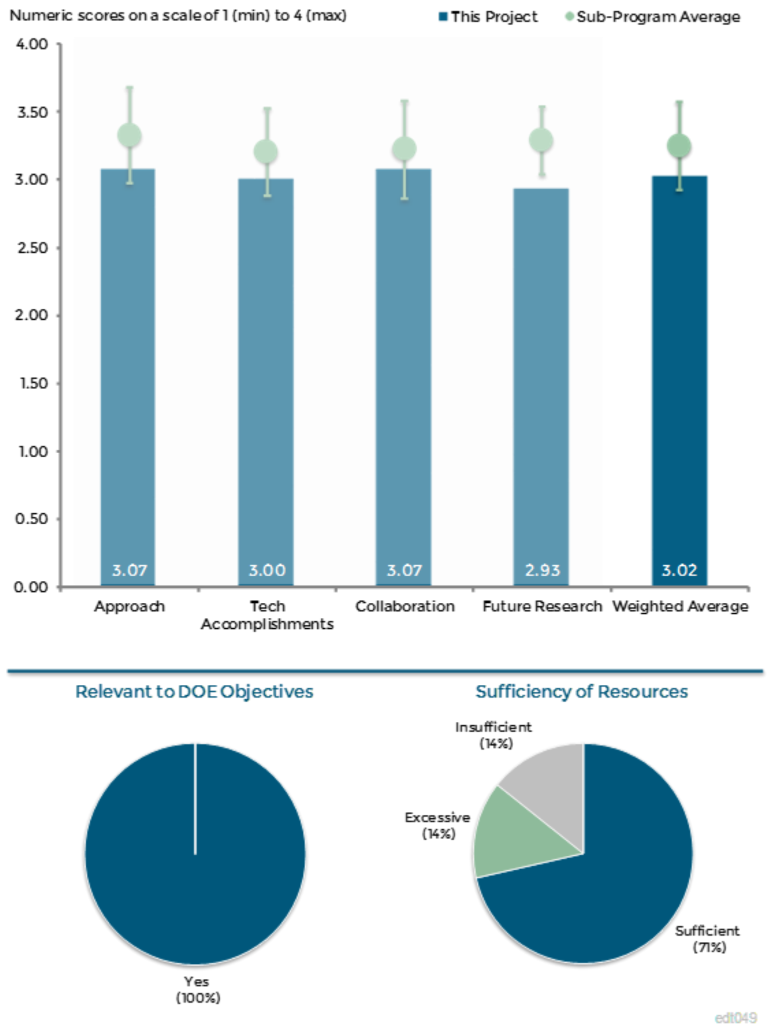

Figure 3-7 Advanced Packaging Technologies and Designs: Zhenxian Liang (Oak Ridge National Laboratory) - Electric Drive Technologies

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer found the project to be well designed and appeared to address several of the barriers, but was not sure that production cost was being considered. This person thought the concepts and prototypes were cool, but was not sure they could ever be commercially viable, and so suggested adding an OEM and/or a module or inverter Tier 1 supplier to the team might help keep this in check.

Reviewer 2:

The reviewer considered the concept for a single package to be interesting, but the scalability of the design was not demonstrated in the current results. Regarding silver sintering, the evaluation of reliability of the bonding technique needs to be addressed, especially for high temperature operation. The reviewer believed that the emphasis on three-dimensional (3D) printing for the fluid manifold design seemed like a weak point for the current strategy, and suggested a simple polymer over-molding technique instead. This person concluded by asking how this approach isolates the coolant from the package itself.

Reviewer 3:

The reviewer saw generally sound work on packaging of WBG semiconductors, but also that the connection to overall system goals needs to be strengthened.

Reviewer 4:

The reviewer relayed that the approach addresses limitations of the state of the art (SOA) technology by replacing Si power devices with WBG devices by using innovative packaging techniques. Using the hierarchical packaging concept, a power converter's parts are integrated to obtain cost reductions, performance, and efficiency improvements. Comprehensive evaluation of the prototype converter shall be performed to assess functionality silicon carbon (SiC) multi-phase converter module.

The reviewer noted that the approach does not address EMI/EMC issues of the proposed power converter, as SiC inverters should have significantly increased value of dv/dt rate. The reviewer saw a need for thermal cycling and power cycling model of the SiC module to be developed. The coefficient of thermal expansion (CTE) mismatch between top layer of the SiC die and lead-frame (planar bonds) also need to be determined.

Reviewer 5:

It was not clear to the reviewer if the planar bond-all (PBA) package consisted of just a number WBG metal–oxide–semiconductor field-effect transistor (MOSFET)s and diodes, or if it was a requirement for the package that the thickness of the die be the same, or if dies of varying thickness could be accommodated.

Reviewer 6:

The reviewer found the approach of replacing Si devices with their SiC and gallium nitride (GaN) counterparts to promote their accelerated adoption in power conversion systems not to be compelling. This reviewer declared that surely the PI is aware that there are a number of companies working in this space already, such as Cree, Rohm, APEI, Powerex, USCi, etc., who already offer SiC power modules that are commercially available. However, the reviewer found the second bullet on Slide 6 to be a compelling reason, because it appears that the innovative power packaging technique offered up herein is the planar-bond-all (PBA) methodology. This reviewer will be interested to see how the PBA methodology truly differs from what has been presented before by packaging experts from around the world.

Slide 7 does not do much to unpack or unbundle the PBA methodology, and the renderings above the words Hierarchical Packaging are neither novel nor innovative. The rendering on the right, above Integrated Packaging shows a conceptual idea demonstrating multi-functional integration, building block, advanced manufacturability, and superior performance. The reviewer asked: what the functions of the multi-functional integration were; what characteristics made the building block a building block, how the building block was used, and how the building block could be used to build up a full inverter; what the advanced manufacturing techniques were; and how the results presented support the claim for superior performance.

The reviewer concluded that Slide 8 is reasonable for a proof of concept package prototype but possesses little resemblance to a sellable product.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer believed that technical accomplishments were on track, and thought it was an impressive, albeit probably really expensive module.

Reviewer 2:

The reviewer thought development of the silver sintering bonding approach was interesting, but observed that issues related to reliability were not heavily addressed. The reviewer was left wondering how this was new relative to the current state-of-the-art in terms of the evolution of the bond structure at high temperature; for example, if voiding and electro-thermal migration of the bond line over time had been analyzed.

Reviewer 3:

The reviewer reported that hardware had been successfully produced, and results published. Improved performance is claimed, with metrics, but it was unclear to this reviewer what the baseline was or how this compares to the WBG packages of others.

Reviewer 4:

The reviewer relayed that SiC planar module packaging is completed, with double sided cooling. Electrical characterization of SiC planar module was completed, performance of the integrated cooling system was evaluated, and electrical reliability test setup of SiC power module was devised. Three-phase SiC module with integrated thermal management was developed. Silver sintering technique was developed as part of SiC module development process.

This reviewer suggested that the PI develop cost of model of the process developed for doubled sided cooled SiC power module including a strategy how it could be scaled for mass production of the SiC power modules. The PI was also encouraged to identify U.S.-based source for equipment used in the module manufacturing processes.

Reviewer 5:

The reviewer determined that the start date shows 2015 but results shown go back into 2014, so this a continuation where the Si devices were replaced with SiC devices and a reliability test set up is proposed. This person asked the project team to quantify the parasitics, the thermal resistance and the manufacturability of this PBA approach.

Reviewer 6:

The reviewer said that Slide 9 shows a standard half-bridge configuration. It appeared to this reviewer that there are no Kelvin connections for either the upper or lower MOSFETs shown. These are required not optional. In the top-right rendering, it appears there are two gate connections with a single wire bond and a third bond pad that goes to the source of each MOSFET die in each switch position. It is labeled “E” here. The reviewer inquired about whether this represents insulated-gate bipolar transistors (IGBTs) versus MOSFETs and thus means emitter, or, whether this represents something else. The reviewer pointed out that one would expect to see many more wire bonds for the source/emitter connection to not only handle the 100 A of current but to minimize inductance.

The reviewer inquired about the following: reasoning for why the lower left schematic shows six terminals on the top left and right compared to the three in the PBA structure above and to the right of it; reasoning for why the jig has four power terminals (i.e., two on each side), but has only one terminal shown on the package on the right side; and reasoning for why the prototype PBA module in the bottom right has five pins and four pins, respectively, when compared to either the 6-6 on the lower left and the 3-3 on the upper right, because this is confusing.

Referring to the top-left picture on Slide 10, the reviewer asked why the bottom pin-fin baseplate is so much larger than the top pin fin, and questioned how one is to physically make electrical connections for V+, V-, and V midpoint. Looking at the top-right rendering, the reviewer inquired about which coolant fluid is to be used, and further emphasized that it appeared it must be a dielectric fluid. The reviewer also expressed interest in the finite element analysis (FEA) and computational fluid dynamics (CFD) results for these structures.

It was unclear how the values shown in the lumped parasitic element model (i.e., Slide 11) were obtained, and asserted that this should be revealed. The reviewer asked why the lumped parasitic element model was not used below in the LTspice electrical performance simulation. It appeared to be much more accurate then what is shown in the LTspice schematic. The reviewer highlighted that no detail is provided for the number and diameter of the wire bonds. The reviewer requested clarification on what the blue bar represents versus the red bar, how Lp is defined, and how Rp is defined because it is not obvious. The reviewer pointed out that there seems to be significant overshoot at the turn-on for the second pulse, and would like to know why.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

It seemed to the reviewer that the coordination between the partners was well-executed.

Reviewer 2:

The reviewer relayed that the PI has identified some key collaborators.

Reviewer 3:

The reviewer noted collaborations with suppliers and with NREL, but thought it would benefit this project to collaborate with industry that is producing packaged WBG modules.

Reviewer 4:

The reviewer felt that the collaboration that industry partners, such as U.S. DRIVE members, had with this project was vague, and who those partners are was not clear.

Reviewer 5:

The reviewer would have liked to see a vehicle OEM and/or a module or inverter Tier 1 on the team to keep an eye on commercial viability

Reviewer 6:

It was not obvious to this reviewer how all the partners have contributed to this work, specifically what UTK has done. The reviewer assumed that NREL was involved in the silver sintering development work, but was not clear on what was done by ORNL and what was done by NREL. The reviewer asked how industry contributed other than sourcing materials, specifically the contributions of Remtech, Masterbond, and U.S. DRIVE members.

The reviewer stressed that the Big Three automotive manufacturers focus on cost, cost, and cost, followed by reliability, and noted that, to date, this information is lacking in this work.

This reviewer affirms the decision by the ORNL team to include the NREL personnel for the thermal and reliability aspects to the project.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer said that some key tasks were identified as part of future research.

Reviewer 2:

The reviewer thought that the items listed on the proposed future research slide are okay but somewhat vague.

Reviewer 3:

The reviewer asserted that greater emphasis should be placed on evaluating the reliability of the full package including the coolant flow through the manifold in contact with the package. Additionally, the reviewer recommended that the effect of high temperature operation on the silver sintered bond line be addressed.

Reviewer 4:

It was difficult for this reviewer to evaluate proposed future research. In this reviewer's opinion, developing high temperature materials, processes, and characterization of high-temperature SiC power modules cannot be done in one calendar year. Some material development work alone has taken 3-5 years.

Reviewer 5:

The reviewer asked for comments on the reliability tests to be performed; if they are targeted at an unpackaged inverter as shown, or just the PBA structure.

Reviewer 6:

The reviewer believed it would be nice to have a target vehicle to verify the designed inverter.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer believed that this packaging of WBG semiconductor modules is needed to bring WBG technology into EVs. This would support displacement of petroleum use in transportation.

Reviewer 2:

The reviewer maintained that the use of SiC-based power electronics has the potential to save or recover significant losses incurred by the use of Si technology, and thus is a worthy technology to be funding.

Reviewer 3:

The reviewer believed that WBG power electronics know-how could be advanced through activities of this project.

Reviewer 4:

This reviewer agreed that lowering the cost of power electronics helps to enable the market for EDVs which reduces our dependence on foreign oil.

Reviewer 5:

The reviewer affirmed that WBG is a technology that has promise for petroleum displacement.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

There appeared to the reviewer to be a lot of work planned in this project and it was not clear that a $650,000 funded program would be sufficient. However, the reviewer also saw no evidence that the resources were not applied appropriately at this time

Reviewer 2:

It is not obvious to this reviewer that this new module has been tested beyond a double pulse test. Driving an electric machine for hours/days/weeks is a whole different beast. This project appears to have started in FY 2014. The period of performance appears to cut across four fiscal years from FY 2014 through FY 2017. This reviewer believed it is time to transition this concept to industry in order to bring it closer to reality – quicker.

Electric Drive Inverter Research and Development: Madhu Chinthavali (Oak Ridge National Laboratory) - edt053

Presenter

Madhu Chinthavali, Oak Ridge National Laboratory.

Reviewer Sample Size

A total of seven reviewers evaluated this project.

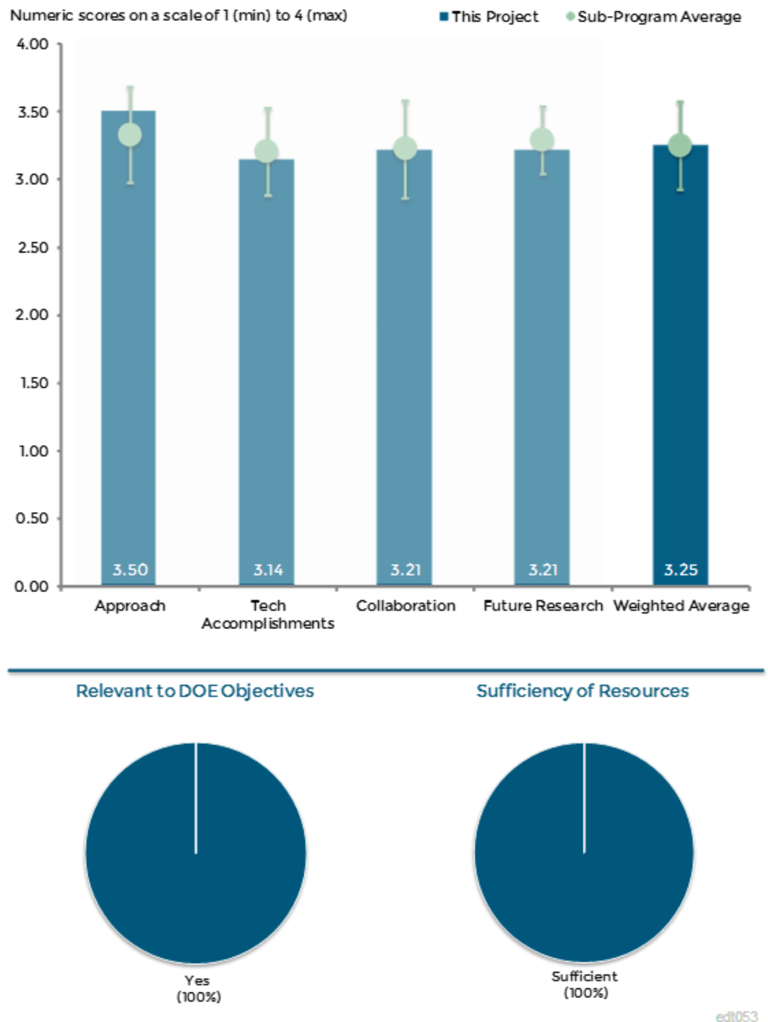

Figure 3-8 Electric Drive Inverter Research and Development: Madhu Chinthavali (Oak Ridge National Laboratory) - Electric Drive Technologies

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer thought this was a very well designed and structured project, but added that more granularity in the FY 2015 timeline would be nice to see so that the project could be tracked with more fidelity.

Reviewer 2:

The reviewer believed that selecting a commercial power module and building an inverter around it is a good approach to establish a baseline, and that then building an inverter for comparison to the baseline was also a good idea. The reviewer asserted that it would be helpful to quantify results by creating a table, which could evolve, to show the comparison points to the baseline. Example data points could be die area, thermal resistance of the power device, fault monitors, switching frequency, etc., and comments could be added below as to how that could improve system cost or performance. The reviewer’s idea of the comparison table would also apply to testing of WBG devices.

Reviewer 3:

The reviewer thought that the air cooling approach for the 10 kilowatt (kW) size is attractive assuming the heat spreading is high, package thermal resistance is low, and the air volumetric flow rate is sufficient. The reviewer pointed out that excessive noise from the air flow and inverter size are also significant barriers, and the primary barriers to this approach. Separately, the 3D printing technology is an intriguing approach, despite the current high cost.

Reviewer 4:

The reviewer reported that the approach is to evaluate WBG devices and develop loss models. The steps involved are to build and test a 10kW air-cooled inverter; design, build, and test a 30 kW WBG-based liquid-cooled prototype; and, by year 3, build a 55 kW WBG inverter prototype at ORNL.

The reviewer encouraged the PI to take an approach that addresses issues with the production intent design. It this reviewer's view, it would be better service to industries if a 30 kW production design is fully completed with reference and application notes released in public knowledge space rather working on three different designs and not able to address practical issues of the production intent WBG power electronics.

Reviewer 5:

The reviewer stated that this project addresses pretty conventional topics, but does so in the context of WBG semiconductors.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer stated that the project is just getting started but still has completed the foundational work needed to build upon later in the execution of the project. The reviewer applauded the use of 3D printing to quickly get air-cooled inverter built, and saw good progress on test and characterization of planar versus trench devices. This person would like to see more on bulk capacitor plans in this project, and also adequately addressed plans for switches, as the project also includes "reduce cost through novel interconnects." The reviewer did not see that covered in the presentation material.

Reviewer 2:

The reviewer observed a new start and that the plan has promise.

Reviewer 3:

The reviewer stated that so far, the results have dealt with a 10 kW air-cooled prototype, protection in a gate driver IC, and double pulse tests. Additionally, there has been 3D printing of parts of the 10 kW prototype, although the investigators have not identified what new performance is gained from this. The reviewer found that investigators need to more clearly identify what technical accomplishments distinguish this project.

Reviewer 4:

The reviewer reported that the volumetric power density for the air cooled inverter is low, as expected, and that this seemed to be the primary drawback to this approach. The reviewer asked what the volumetric power density benefit for the 3D printing approach was, because it was not fully clear. This person also wondered what specifically had been simplified with regard to electrical connections, packaging, cooling, etc.

Reviewer 5:

The reviewer reported that a 10 kW WBG inverter using ORNL SiC devices had been built and tested. Double-pulse set-up is developed. Static characteristics and switching losses of planar and trench SiC MOSFETs are compared. Protection functions of SiC MOSFET driver are demonstrated. 3D printed air-cooled inverter model is developed. This reviewer thought it would have better if an X-ray picture of module was taken after 100 hours testing and degradation of the power module assessed.

Reviewer 6:

The reviewer recommended the project team focus on the water cooled design, because it is hard to investigate both air cooled and water-cooled in one program.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer said that it looked like there is good inter-lab collaboration on this project.

Reviewer 2:

The reviewer thought the choice of partners was good.

Reviewer 3:
The reviewer imparted that there is collaboration with suppliers and with NREL.

Reviewer 4:
The reviewer saw collaborators for device prototype suppliers, customer capacitors suppliers, and thermal analysis support reported in report submitted for DOE-AMR 2015.

Reviewer 5:
The reviewer related that there was a good who's who of WBG device suppliers on the team and well as capacitor suppliers. It was not obvious to the reviewer what the cap suppliers are contributing, or who if anyone the project team is partnering with for interconnection of low voltage components.

Reviewer 6:
The reviewer said that the evaluation of SiC is becoming more complex as more suppliers and more parts are entering the market, and assumed that the trench-planar SiC MOSFET comparison was with one supplier. This reviewer would suggest in the future to include a summary for the power transistor by manufacturer, voltage, generation number, specific RDSON, EON, and EOFF.

The reviewer also wondered if there may be a better way to do this graphically, but both SiC users and SiC manufacturers could benefit from an independent, objective analysis.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer decided the push towards higher-power inverters seems to mirror the industry needs. As shown by the Tesla model, the move to put higher-power EV or xEV vehicles in the premium category is a good way for advanced technology to penetrate automotive market until volumes and costs decrease. The reviewer revealed that there is a great deal of activity in the European Union market to respond to Tesla's challenge, with premium sports or luxury vehicles, with 100-300kW of power in the drivetrain. This reviewer concluded that WBG semiconductors should fit this need well.

Reviewer 2:
The reviewer thought the approach was a good start with a clear direction for the future, but wondered if the smart gate drive circuit in 2017 was coming from this project or another project.

Reviewer 3:
The reviewer decided that tasks and topics for future research seems appropriate; however, tasks and topics do not address problems faced by industries.

Reviewer 4:
The reviewer was not clear on decision points, but believed that the FY 2015-FY 2017 tasks are the logical progression of the project

Reviewer 5:
The reviewer was concerned about the size and air flow requirement for the proposed 55 kW air-cooled inverter proposal. This may be the primary limiter and need to be fully addressed.

Reviewer 6:
The reviewer pronounced that the investigators need to better make the case for what technical accomplishments could come out of this project that would distinguish it from others.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

Working on all aspects of lowering the cost, and increasing the power density, of the electric drive train. Power density and efficiency are improved through the use of advanced technologies in additive manufacturing, advanced packaging, and WBG semiconductors.

Reviewer 2:

The reviewer anticipated that 3D printing of electronics would be the future, so this seemed highly relevant, although maybe not for extremely high volume applications.

Reviewer 3:

The reviewer concluded that WBG inverter technology could aid in performance of EVs.

Reviewer 4:

The reviewer disclosed that the project aims to develop WBG power electronics know-how, but opined that it would be nice to release design application notes.

Reviewer 5:

The reviewer reasoned that improving the cost and performance of power electronics helps to enable the market for EDVs, thus reducing our dependence on foreign oil.

Reviewer 6:

The reviewer expected that big gains will come from the WBG portions of the project, but that commercial viability of three-terminal WBG in the DOE's planning horizon is questionable

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer thought it seemed to be resourced and funded appropriately.

Innovative Technologies for Converters and Chargers: Gui-Jia Su (Oak Ridge National Laboratory) - edt054

Presenter

Gui-Jia Su, Oak Ridge National Laboratory.

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

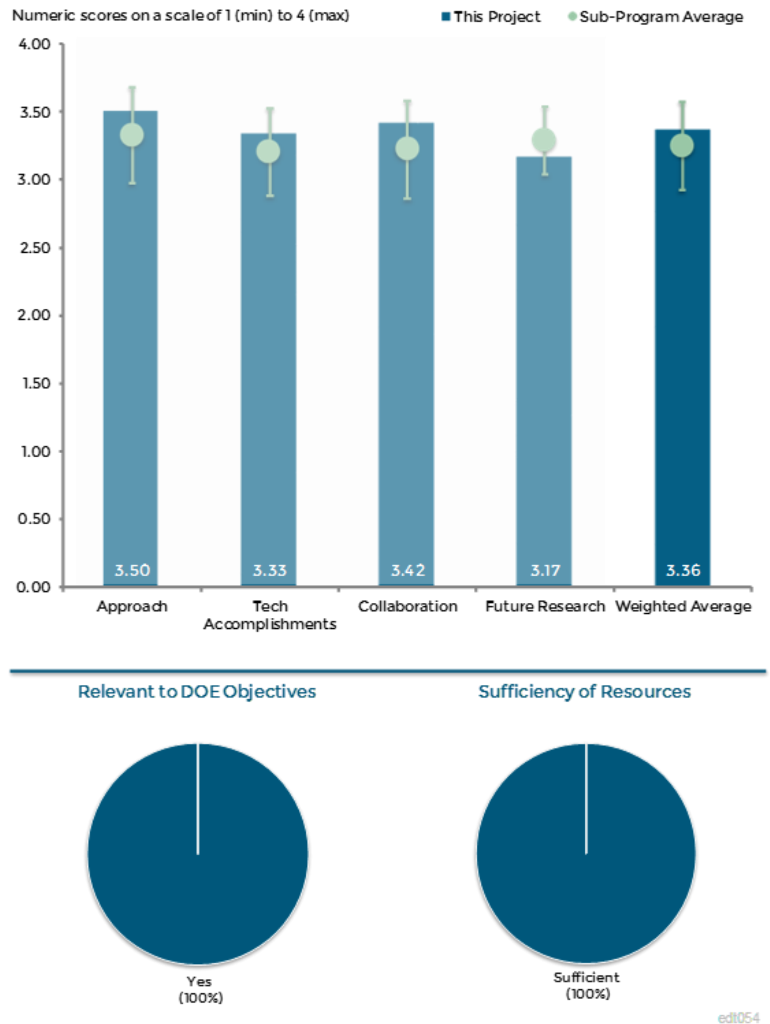

Figure 3-9 Innovative Technologies for Converters and Chargers: Gui-Jia Su (Oak Ridge National Laboratory) - Electric Drive Technologies

Reviewer 1:

The approach appeared to the reviewer to be versatile and applicable to a variety of vehicle architectures. The ability to charge the accessory battery is additionally a beneficial feature. The reviewer asked if there is a specific size target for the system.

Reviewer 2:

The reviewer described this as a well-designed technical approach that appeared feasible and is addressing issues.

Reviewer 3:

The reviewer said this was one of several competing projects in this area. This project employs WBG MOSFETs, a dual-active bridge circuit for isolation and control, a 14 V charging output, integration with inverter and machine windings, and planar transformer.

Reviewer 4:

The reviewer thought that Slide 6 nicely summarized a reasonable approach to be used. The bottom figure portrays a 240/120 V input to the traction drive motors and SiC inverters. This AC input must be rectified so as to establish the input DC bus for the isolated DC-DC converter. The reviewer determined that Slide 7 implies that the traction drive acts as the on-board charger (OBC) alternating current (AC)-DC front end, but exactly how this will be done would be helpful to see. This person asked if the PI assumed an intervening DC-DC converter between the battery pack and the traction inverter input. The latter four attributes of the OBC are all important to demonstrate within this project.

In Slide 7, this reviewer believed that the use of planar magnetics for transformer Tr is a good direction to pursue for the all-WBG converter. The reviewer agrees that the dual active H-bridge is a most promising topology for the isolated DC-DC converter. The reviewer believes it is important to consider the spatial distribution of the following subsystems: The 240/120 V source, the traction inverter, the interior permanent magnet synchronous motors (PMSMs), the WBG isolated DC-DC converter, the car's battery pack, and the 14 V battery for auxiliary loads. The parasitic resistance and inductance associated with cabling/bussing among these subsystems could be significant – thus having an impact – when integrating this approach into a PHEV.

Slide 8 states the flexibility of this solution to various traction drive system architectures. The reviewer thought it would be worthwhile to provide the circuit description for each. This reviewer also recommended that the Slide 9 goal of better than 96% should include an input filter between the 240/120 AC system and the rectifier; and similarly, it should include an output filter between the isolated DC-DC converter and the battery pack. The input filter could possibly be motor windings.

Reviewer 5:

The reviewer restated that the approach is to overcome the limitations of present semiconductor and magnetic materials with WBG devices and advanced magnetic materials. This is expected to increase power density, specific power and efficiency at lower cost, and to further reduce cost by using novel integrated topologies and control strategies. The adopted approach offers the following aspects: it could be useful in most traction drives; isolation converters can be applied standalone on OBC; developed converters have bi-directional power flow; and use of WBG devices enables high efficiency and high power-density.

The reviewer suspected that these claims may not be universally valid, for example, OBC uses electric machines in charging circuit and machine inductance varies over a wide range depending upon number of poles and types of electric machine used. High-pole count PM machines are getting very popular due to their smaller weight and size and they have much smaller leakage inductance than induction machines.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer saw good progress to date, and reported that the topology, and WBG switches are progressing well. It is not clear to this reviewer what the real progress and plans are for magnetics although the right partners are there for this.

Reviewer 2:

The reviewer thought there were good preliminary results. Nano-magnetic powder material is an exotic transformer with possible long-term research implications.

The reviewer reminded the investigators that in the early designs that evolved into the GM EV-1, a charger used the machine windings as well. This eventually was abandoned because the common-mode currents caused by capacitance from machine windings to vehicle frame were excessive. The current approach employs additional means of isolation, so it is not clear what the implications will be regarding common-mode leakage during charging and the associated difficulty in meeting safety standards. The reviewer wondered if perhaps the investigators should consider this.

Reviewer 3:

The reviewer said the system appeared to have a high efficiency, but was concerned with the overall size of the system, and so recommended a focus on downsizing the package be considered in the future.

Reviewer 4:

The reviewer reported that Slides 11-13 demonstrate the high efficiency of the 6.6 kW SiC-based isolated DC-DC converter alone from FY 2014. This person asked what the continuous and peak rating of the SiC traction drive that was presented on Slide 14 was. The peak charger system efficiency was 96.5%. This appeared to the reviewer to be at nearly 4 kW of output power according to Slide 14 and Slide 15. This person would be interested to see documented efficiencies at 120 V AC input, instead of 240 V. The reviewer thought Slide 15 would have been better if the Si IGBT and MOSFET data points aligned with the SiC MOSFET data points so a true comparison could be made.

The reviewer asked if the AC/DC converter portion of the OBC had closed-loop control of the AC current with grid synchronization in Slide 16, if there was a closed loop DC-link voltage control, if it complied with EN 61000-3-2 limits, if the investigators had switched this block at 1 MHz or above, and why the 6.6 kW SiC AC-DC front end drops off so quickly at light loading. At an output power of ~1 kW, this reviewer would expect an efficiency greater than 97%, greater than 98% at 2 kW, etc.

The reviewer said Slide 18 shows preliminary results for a normally-on GaN device from IR/Delphi, and wondered what resistance was used to ensure stable switching in the Cascode configuration, since none is shown.

Reviewer 5:

The reviewer believed the prototype designs developed in this project do not address production issues. The reviewer restated that the 2 kW 14 V converter is built using ORNL packaged SiC switch based off Cree SiC MOSFETs. Planar magnetic is used, which offers improved thermal management; heavy copper pour printed circuit boards (PCBs) are used. Peak efficiency of 97.5% to 99% is obtained. Test results of 6.6kW SiC charger are demonstrated. 3.3kW GaN isolation converter design is competed and prototype hardware is tested. Aegis Technology is engaged in development of transformer core design for GaN based charger.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer exclaimed that there was a great team of partners and collaborators.

Reviewer 2:

It seemed to the reviewer that the collaborating partners are working well together, although this could have been better highlighted in the presentation.

Reviewer 3:

The reviewer judged the external collaborations to be appropriate, although it would be appropriate to collaborate with potential end users of this work.

Reviewer 4:

This reviewer’s appraisal was that this is a solid team that should be capable of carrying out this effort. It appeared to this person that collaboration and coordination among the team members is present.

Reviewer 5:

The reviewer reported that Infineon, Delphi, RoHM, Aegis Technology, Hitachi/Metglas, Ferroxcube, and NREL are collaborators in this project as per the report the PI submitted for DOE-AMR 2015.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer pronounced that the proposed remaining work is a logical continuation of this project.

Reviewer 2:

The plan seemed reasonable to this reviewer.

Reviewer 3:
The reviewer thought everything looked good on topology and WBG switches, but the magnetics approach and future work was not clear.

Reviewer 4:
The reviewer asked the investigators to please look into the size reduction of the system, specifically reducing the two-dimensional footprint, as this technology is transitioned/licensed to collaborative partners. This reviewer wondered if there were any EMI safety concerns for the placement of this system in the vehicle.

Reviewer 5:
The reviewer stated that 6.6 kW all GaN isolation converter build is suggested within project activities to take place during FY 2016. This will be followed by integration of 6.6 kW GaN converter with WBG traction drive. The PI also suggests that OBC shall be characterized. The reviewer reiterated that production issues were not addressed, such as EMI/EMC issues are missing from project tasks for the future research.

Reviewer 6:
This reviewer concluded that it would be nice to conduct EMI testing and see if it meets the charger requirements.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
A versatile and efficient onboard charger has significant potential for future electrified vehicles.

Reviewer 2:
The reviewer considered this project to contribute directly to the adoption of PHEVs and the reduction of GHG emissions via the use of WBG semiconductors to obtain increased efficiencies.

Reviewer 3:
The reviewer related that this advances WBG power electronics know-how and could support DOE-APEEM targets.

Reviewer 4:
The reviewer found that WBG, Novel topologies, and advances in magnetics are all needed to converge for a unified petroleum displacement strategy.

Reviewer 5:
The reviewer estimated that improved onboard charging is needed to enhance the general acceptance of EV and PHEV systems.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer stated that this appears to be a three-year long project spanning FY 2014, FY 2015, and FY 2016. In the first two years, nearly $1.7 million was either spent or will be by 9/30/2015. This reviewer presumes that another estimated $850,000 is yet to come in FY 2016. Resources appear to be more than adequate for this work.

Advanced Low-Cost SiC and GaN Wide Bandgap Inverters for Under-the-Hood Electric Vehicle Traction Drives: Kraig Olejniczak (APEI, Inc.) - edt058

Presenter

Kraig Olejniczak, APEI, Inc.

Reviewer Sample Size

A total of six reviewers evaluated this project.

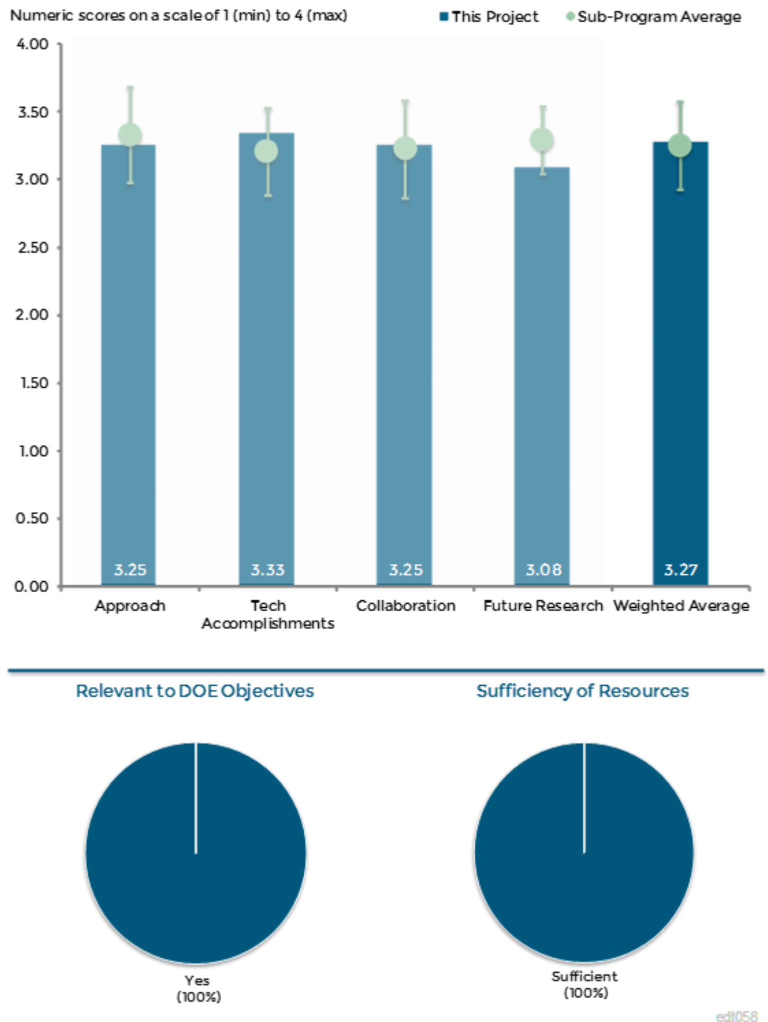

Figure 3-10 Advanced Low-Cost SiC and GaN Wide Bandgap Inverters for Under-the-Hood Electric Vehicle Traction Drives: Kraig Olejniczak (APEI, Inc.) - Electric Drive Technologies

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer reported that the project is looking both at SiC and GaN, with a focus on packaging and its performance which is desperately needed, but that it really left cost out of the equation.

Reviewer 2:

The reviewer decided the approach was logical and to the extent the technical barriers are addressable, and the project was well designed. At this point in the project, some of the feasibility is called into question, especially if the GaN portion of the program get there.

Reviewer 3:

The reviewer suggested that the approach should state what those clever ways are to make apples to apples comparisons.

Reviewer 4:

The reviewer reported that this project advances know-how in the area of WBG power electronics by developing SiC and GaN traction inverters. GaN high-electron mobility transistor (HEMT) power device shall be advanced resulting in its probable application in a product that could be successfully commercialized. This project also aims to advance WBG inverter packaging and thermal management concepts including cost reductions by using in-house design of high temperature silicon on insulator (HTSOI) IC. Module package capable of the high temperature (250°C) applications shall be developed through this project. The reviewer concluded that this project does not address numerous issues related to the production intent design, what would be kW/liter, kW/kg and $/kW SiC and GaN inverters address commonly known production issues, such as EMI/EMC, dv/dt, and di/di problems.

Reviewer 5:

The reviewer relayed that the project is developing advanced EV power electronics using WBG switches.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer declared that the progress, given the funding level and size of organization, has been excellent.

Reviewer 2:

The reviewer pronounced that this project had made reasonable progress.

Reviewer 3:

This reviewer said that progress on the inverters is progressing, but wondered what the comparison points are.

Reviewer 4:

The reviewer decided that the few technical accomplishments that were noted were good, and was impressed by the module inductance. This reviewer pointed out that no mention of the estimated production cost of such an inverter or switch was made, just several references back to GM estimated costs, which were not provided either. No doubt one can make a WBG inverter, and make it smaller, and make it lighter, and make it more efficient, but this reviewer wondered if it could be commercially viable in the DOE stated planning horizon for this project.

Reviewer 5:

The reviewer reported that the prototype SiC inverter is tested up to 30kW and efficiency of the inverter is determined. Power module is characterized over 25°C to 125°C for key parameters, such as, Rds on and Vds versus Ids data including clamped inductive load testing. Thermal analysis of the inverter assembly is carried out. Accelerated thermal testing of interface material is carried out to evaluate reliability of module.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer thought that having an OEM collaborate on designs is excellent, and that having the OEM use the design is outstanding.

Reviewer 2:

The reviewer concluded that APEI has good collaboration with NREL on modeling and GaN systems.

Reviewer 3:

The reviewer reported that Toyota, GaN Systems, NREL and University of Arkansas are collaborators in this project.

Reviewer 4:

This reviewer relayed that the project team was engaging OEM, suppliers, and national laboratories.

Reviewer 5:

The reviewer deduced the project team was ultimately designing, building, and testing an inverter in this project. This reviewer would have liked to seen a Tier 1 inverter partner or been advised on how Toyota was representing this competency and/or point of view.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer stated that the team may work with Toyota to test their system in a vehicle, and that more cost analysis should be provided.

Reviewer 2:
The reviewer believed that there was lots of work left to do on this project and very little time

Reviewer 3:
The reviewer was not clear how other areas, like changes in control strategies to improve efficiency are impacted by this comparison, because the approach seemed to be focused on SiC versus GaN.

Reviewer 4:
It is not clear to this reviewer if this prototype includes the EMI filter, and asked that if it does, to please show the EMI test result next time.

Reviewer 5:
This reviewer said that given time and resources, future research looks impractical.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer found that this project addresses DOE's quest for WBG power electronics, and speculated that it could be possible DOE-APEEM target could be met and/or exceeded.

Reviewer 2:
This reviewer decided that was one approach to meet DOE cost and performance targets is using the WBG switches. The team may provide a roadmap on potential cost reduction of WBG switches and their power inverters.

Reviewer 3:
This reviewer agreed that evaluating different approaches to reduce power electronics costs helps to lower the cost of EDV's and reduce our dependence on foreign oil.

Reviewer 4:
The reviewer supposed that if successful and commercially viable, the project would support the DOE goal, but questioned where the production costs will land, and therefore the viability.

Reviewer 5:
The reviewer relayed that the project looks at the application of WBG and how to gain the most out of these types of devices.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer said they seemed adequate.

Reviewer 2:
This reviewer agreed that the team and its partners have all the resources to achieve the stated milestones.

High-Temperature DC Bus Capacitors Cost Reduction and Performance Improvements: Angelo Yializis (Sigma Technologies International) - edt059

Presenter

Angelo Yializis, Sigma Technologies International.

Reviewer Sample Size

A total of six reviewers evaluated this project.

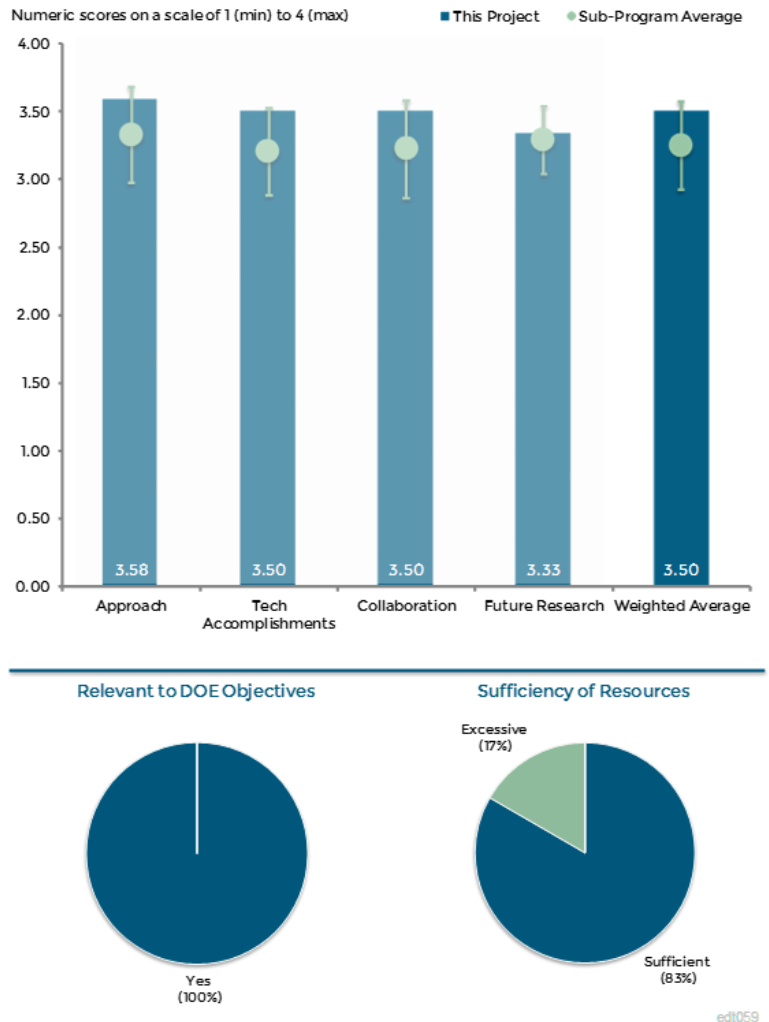

Figure 3-11 High-Temperature DC Bus Capacitors Cost Reduction and Performance Improvements: Angelo Yializis (Sigma Technologies International) - Electric Drive Technologies

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer saw that the project appeared to be organized and coordinated with capabilities of project partners. The project incorporates an automotive supplier with experience in requirements and challenges associated with the use of capacitors in automotive electric drive applications. The project also appeared to the reviewer to be actively involved in efforts to commercialize the technology.

Reviewer 2:

This reviewer thought that the approach being implemented on this project has potential to transform the capacitor industry, while addressing the goals set forth for this project. The presenter displayed a high level of competency in conventional capacitor technologies and their limitations, and clearly presented the advantages that distinguish this approach from conventional methods. This reviewer was concerned that this is a relatively new processing technique for capacitors, and quality control for mass production may require additional research beyond the demonstration scale and low volume production.

Reviewer 3:

The reviewer declared that the process of build, test, and improve the design has been proven to work on numerous programs and should work here. Also the approach is addressing the basic issue with bulk caps of today: larger, heavy capacitors with limited temperature range and lower ripple capacity as a function of increasing temperature. This project is developing a new capacitor based on new, ultrathin high strength dielectrics that promise to create high energy density capacitors capable of high temperature operation. The approach includes developing a package optimized for this construction technique that is appropriate for the automotive environment. The team is also building a model of the capacitor capable of supporting thermal modeling of capacitor temperatures over various drive cycles, which aid in inverter design. The reviewer concluded that the sample package shown during the meeting will be impressive if it works.

Reviewer 4:

The reviewer stated that Sigma has a novel technology for fabricating multilayer polymer capacitors through sequential monomer and electrode deposition in a large-scale vacuum system. The capacitors have a high volume efficiency and low equivalent series inductance and the polymers have been specifically formulated for high temperature operation.

The reviewer further relayed that the goal is to replace large and heavy DC link capacitors that are fabricated by co-winding metallized polymer films. In addition, current polypropylene capacitors will not operate above 105°C under high ripple currents. Sigma's acrylate-base polymers will be able to operate above 140°C.

Reviewer 5:

The reviewer reported that the approach was to integrate the entire capacitor manufacturing chain in one step.

Reviewer 6:

The reviewer indicated that the approach of this effort is to develop a solid state polymer-multi-layer (PML) with prismatic shape to overcome limitations of polypropylene DC-link capacitors in transportation electrification applications. It has lower equivalent series inductance (ESL) and equivalent series resistance (ESR) in comparison to the state of the art. Its operating temperature is in the range of -40°C and 140°C

The reviewer believed it would be useful to include more information on what is expected regarding operation life cycle/time of the proposed technology and also some information on the method of determining such information.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer said that the presenter provided detailed information that confirms this project addresses DOE goals, particularly the volume and cost of the capacitor. This person saw that progress had clearly been made in several areas including critical successes with the process development/setup.

Reviewer 2:

The project appeared to the reviewer to have made significant progress in demonstrating the ability to produce capacitors with performance at high temperatures. This person suggested that it would be helpful to compare the expected performance in terms of cost and volume to the DOE targets.

Reviewer 3:

The reviewer believed that the team is making very good progress toward delivering a production capacitor, and summarized their results: The team has developed a set of capacitor values based on past inverter project bulk capacitor requirements. This has been used to develop a baseline area for the generic capacitor building block which supports a cost effective method of supporting multiple capacitor values in production. Process development has continued with upgrades to the pilot line and an improved passivation process. The reviewer further commented that initial tests indicate that this process has the potential to develop excellent capacitors for use in an inverter. Additional progress has been made in the thermal model which will allow Delphi to characterize the thermal flux performance of the capacitors.

Reviewer 4:

The reviewer detailed that a majority of the reported effort was for optimizing the end terminations. After fabrication of the multilayer polymer monoliths, the ends are subjected to plasma to expose the electrodes. The resistance of the end terminations must be reduced for low ESR and high ripple current. The surface resistance was as low at 10 milliohms/meter; however, the targeted surface resistance was not defined. Life tests were performed at temperatures between 125°C and 160°C. The reviewer thought it would be useful demonstrate capacitor reliability as a function voltage and temperature in the future.

The reviewer conveyed that excellent energy densities were reported at room temperature and high electrical field.

Reviewer 5:

The reviewer affirmed that the technical accomplishments and goals include reducing the cost, size and weight of the DC-link capacitors by at 50%, while increasing the durability of the capacitor operation in high temperature environment.

Reviewer 6:

The reviewer reported that prototype capacitors with large capacitance have been produced.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer saw that the collaboration with the automotive supplier appeared to be very strong in the project to help understand the performance requirements of the capacitors for automotive applications. The presentation also mentioned that there are plans to include a capacitor OEM in the future.

Reviewer 2:

This reviewer declared the collaboration with Delphi and the DOE laboratory was excellent.

Reviewer 3:

The reviewer determined that the project involved a good combination of expertise including an application-oriented partner and other experts in processing and materials science.

Reviewer 4:

The reviewer confirmed that the team has the appropriate skills to complete the task and seem to be working well together based on the results to date. This person asked when the capacitor manufacturer will be added to the team.

Reviewer 5:

The reviewer reported that there is a collaboration between Sigma Technologies, Delphi and ORNL.

Reviewer 6:

The reviewer relayed that the program team members involve an inverter manufacturer (Delphi) and a national laboratory (ORNL). Delphi provides testing and guidance for capacitor banks that will comprise the DC bus capacitor. ORNL will develop thermal models for difference capacitor configurations.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer believed that future efforts for this project are well planned, including next generation capacitors, more detailed cost analysis, and development of a business plan.

Reviewer 2:

The reviewer declared that the future work related to cost analysis seemed to be a critical element of the project to determine if the developed capacitors can support the push to reduce costs of the electric drive system.

Reviewer 3:

The reviewer reported that the proposed work continues the build, test, fix process along the path to the final product. The tasks identified are appropriate for this project. The only item that this reviewer had any concern with was the voltage rating of the part – if 600 Volt would be high enough for potential boosted systems of the future, which will be using 750 to 900 Volt devices and may see a boosted high-voltage bus of 600 to 650 Volt.

Reviewer 4:

The reviewer commented that future work may invest more time to test the capacitors under the EV condition, such as applying large ripple current at elevated temperatures. The reviewer thought it would not be very useful to test the capacitor under DC without ripple, and that it was still not very clear whether the plasma etching can help the electrical connections and carry high ripple current.

Reviewer 5:

The reviewer described how the project team will complete the additional pilot line improvements. The complete package design and the evaluation of first and second generation of capacitors will be done during 2015. During 2016, testing of the packaged PML DC-link capacitors will be conducted. In addition, it will be implemented and tested on a Delphi inverter. Furthermore, the business plan transition into production will be conducted in 2016.

Reviewer 6:

The reviewer relayed that the scale up plans have been implemented to produce 800 microfarad DC-link capacitors operating at 400 V. The targeted temperature range and volume requirements have been specified. The reviewer asked if ripple current will also be measured for the capacitor banks.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer explained that this project supports the DOE objectives to reduce petroleum because smaller, cost effective, and more robust capacitors would enable reducing the size of existing inverter systems for electric drive technologies. The reduced size could make electric drive technologies cost less and make them easier to package within the vehicle to support a wider range of uses.

Reviewer 2:

The reviewer declared that the summary chart, Slide 31, indicates that this project will meet or exceed the DOE goals for capacitors, which are one of the largest components in today's inverters.

Reviewer 3:

The reviewer reasoned that smaller, lower cost capacitors will facilitate the electrification of powertrain, thereby yielding higher fleet fuel economies.

Reviewer 4:

The reviewer stated that DC link capacitors are a critical component in power inverters for electric vehicles.

Reviewer 5:

The reviewer reported high temperature and cost reduction.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said that the resources appear to be sufficient and the project appears to be making good progress.

Reviewer 2:

This reviewer shared that opinion that the project is on schedule and resources are sufficient.

Reviewer 3:

The reviewer said the project has unique capabilities and close collaborations with critical partners.

Reviewer 4:

This reviewer indicated that there are enough resources among the three partner institutions to successfully carry out the proposed work.

High-Performance DC Bus Film Capacitor: Dan Tan (General Electric) - edt060

Presenter

Dan Tan, General Electric.

Reviewer Sample Size

A total of six reviewers evaluated this project.

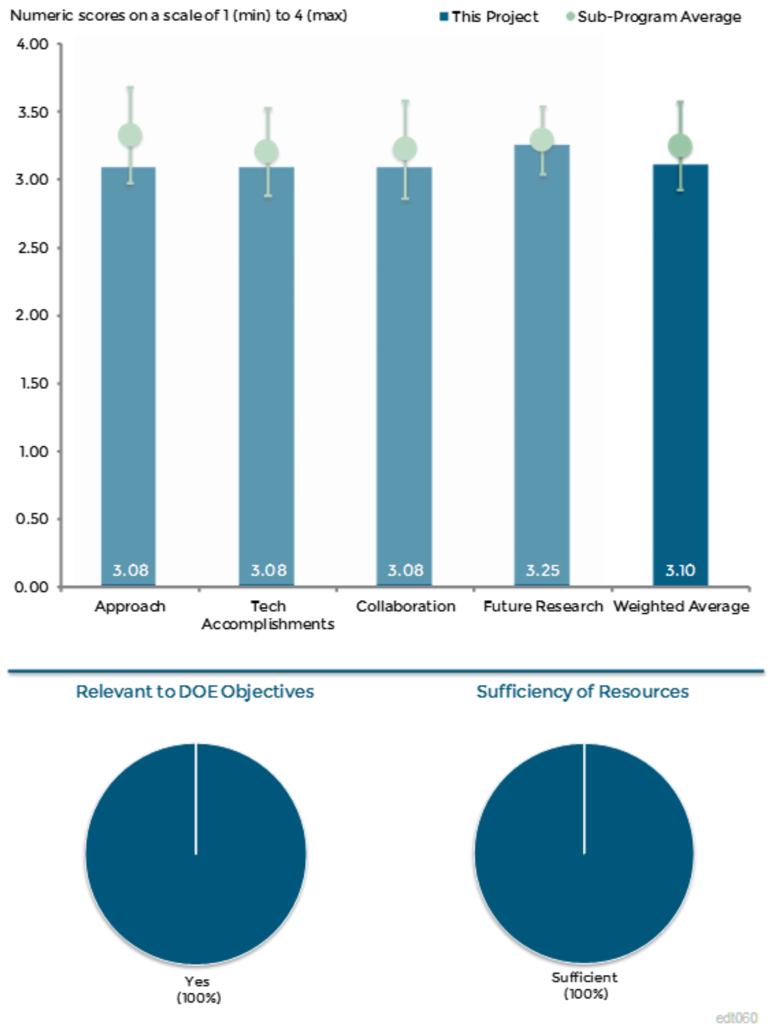

Figure 3-12 High-Performance DC Bus Film Capacitor: Dan Tan (General Electric) - Electric Drive Technologies

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer found the approach implemented on this project to be generally well-planned, as it utilizes existing processing techniques, but predicted that it will require some challenging process variations/improvements as thinner films are targeted.

Reviewer 2:

The reviewer reported that the development effort focuses on thinning polyetherimide (PEI) film, which is a commercially available material. This dielectric has sufficient properties to meet the DOE specifications for DC link capacitors including high temperature performance and low dielectric loss. This reviewer anticipated that this material will enable capacitors to operate at high ripple capability at high temperature. Thickness reduction is the main goal with dielectric layer thicknesses in the three to five microns. Thinner layers will increase the volumetric efficiency and lower the overall capacitor cost.

Reviewer 3:

The reviewer judged that the project covered an important technological topic, but noted that some of the system level parameters are not clearly outlined and correlated to the materials. This person asked the project team to please provide more information, such as mathematical modeling, to prove how the project team will achieve the 200,000 hour claimed operating life.

Reviewer 4:

The reviewer said that the project appeared to be focused on improving the dielectric constant and being able to produce a thinner film to reduce volume and cost. This person asked if there were other significant barriers that are expected when the project transitions into building capacitors, and what test criteria would be applied to the fabricated capacitors.

Reviewer 5:

The reviewer thought that the approach is typical for a new film capacitor, but was concerned about the upper temperature limit of 180°C, which appears to be related to aerospace more than automotive. This person wondered if it was driving the cost of the capacitor. The team is using multiple film suppliers and is optimizing the correct parameters in terms of film capacitors. The reviewer liked the early involvement of mainline capacitor suppliers as it enables production parts sooner.

Reviewer 6:

The reviewer suggested that the project may invest more on film processing and cost analysis.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer saw a wide range of technical accomplishments on this project, which indicates that there is a great likelihood of incremental success through well-formulated process development and experimentation.

Reviewer 2:

The reviewer agreed that there was significant progress on producing 3um thick PEI film.

Reviewer 3:

The reviewer said the project had evidently worked with production extruders to scale up the process. The material appears to be capable of operating at high temperatures. It appeared to the reviewer from the presentation that work is continuing to overcome defects within the extruded film. The work to reduce defects within the film appears to be the current challenge. Despite the challenges the project says it is on track to produce a capacitor. The reviewer suggested that it might be useful to compare the state of the current material and the project goals to the DOE targets. Most of the slides appeared to focus on the extruded films. This reviewer concluded that some information on the progress associated with the nano-coating of the films to enhance dielectric strength would be of interest.

Reviewer 4:

The reviewer believed that progress is reasonable but was concerned that the aerospace performance goal is impacting the overall progress. The reviewer understands the need to support both. Film processes are improving from multiple suppliers using different processes. The reviewer revealed that the go/no go decision point is coming up and will require six capacitors of specified requirements, but those requirements were not specified. This person concluded that there has been good progress made, but there are still lots to be done and was unsure if the schedule will be met.

Reviewer 5:

The reviewer requested the project team to please provide additional information on what are the typical values of capacitances (in terms of farad) that this project has so far developed and what will be the target values at the end of project. This person asked what the volume is currently, and what the lifetime and reliability are currently like.

The reviewer also requested a graph or some numerical examples representing size of the capacitor for various power levels for car inverters, information on mechanical properties/thermal properties, and ESR/ESL parameters by the capacitor size.

Reviewer 6:

The reviewer reported that PEI films have been fabricated in the 3-5 micron range, with the dielectric permittivity, loss and breakdown of the films as a function of temperature fully characterized.

The reviewer was of the opinion that films in the three-micron thickness range will remain a challenge. Nanolayered silica coatings on the PEI films have shown improvement in the room temperature dielectric breakdown. The reviewer thought it would be interesting to also characterize the dielectric breakdown of silica coated PEI at 150° C.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer remarked great collaboration with film manufacturers and Delphi.

Reviewer 2:

The reviewer remarked that the project includes collaboration and coordination with key members of the capacitor industry and suppliers, as well as an application specific collaborator.

Reviewer 3:

The reviewer summarized that GE’s team is made up of an inverter supplier for requirements, extruded film suppliers, and appropriate suppliers of the required expertise, which seem to be working well together or at least on their tasks. The reviewer believed that the expertise is available to complete the project.

Reviewer 4:

The reviewer said that the collaboration with partners appears to be strong. The collaboration with an automotive supplier appears to be beneficial, but it seems their involvement will become more critical once a capacitor is produced that can be tested. The project appears to have established strong partnerships with various suppliers along the supply chain.

Reviewer 5:

The reviewer observed that GE is collaborating with two independent film manufacturers to scale the PEI materials into mass produced film. There are also plans to team with companies along the entire capacitor manufacturing supply chain. The reviewer detailed that in addition to the film manufacturers, GE will engage with companies specializing in metallization and capacitor fabrication.

Reviewer 6:

The reviewer acknowledged that there is a collaboration between GE and Delphi to develop new material to develop high temperature capacitors. The reviewer believed there should be collaboration between these DOE funded companies and at least a university partner.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer believed that the future plans, which target the primary barriers associated with the transition to thinner film capacitors and fabrication of prototype thin film capacitors, are crucial.

Reviewer 2:

The reviewer stated that it is critical to invest more on film processing and the valuation of the capacitors under HEV power inverter conditions.

Reviewer 3:

The reviewer judged the proposed future work to be appropriate for the current state of the project. The tasks continue the existing development path relative to films and processing.

Reviewer 4:
The reviewer revealed that GE will continue to optimize the PEI film quality for thicknesses less than 5 microns. Specific milestones include the fabrication and testing of prototype capacitors.

Reviewer 5:
The reviewer indicated that the future work appeared to focus on developing the film material and nano-coating. The future work related to cost analysis is important to determine if the new materials and processes are compatible with the need to reduce cost. The future work lists building and testing capacitors, but this person thought that more information would be beneficial because this appears to be a critical step in the project to demonstrate success.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer declared that this project supports the DOE objectives to reduce petroleum because smaller, cost effective, and more robust capacitors would enable reducing the size of existing inverter systems for electric drive technologies. The reduced size could make electric drive technologies cost less and make them easier to package within the vehicle to support a wider range of uses.

Reviewer 2:
The reviewer affirmed that high temperature capacitors are critical to the DOE program target.

Reviewer 3:
The reviewer detailed that this project supports the DOE objectives through introducing novel capacitors with potentially lower size and hopefully longer lifespan or reliability. This would be very useful in advancing the field of power electronics, as DC-link electrolyte capacitors are one of the points of failure for power electronics interfaces.

Reviewer 4:
The reviewer believed that the results were promising in that incremental improvements are likely, which address DOE objectives. Quality control on films that are 4µm and thinner may be a major limiting factor in fully reaching DOE goals.

Reviewer 5:
The reviewer considered DC bus capacitors to be a critical electronic component on power converters for electric vehicles, and speculated that high temperature capacitors may eliminate costly cooling loops and reduce overall system cost.

Reviewer 6:
The reviewer pointed out that this is one of three capacitor programs aimed at reducing the size and cost of the bulk capacitor, which is one of the largest components in the inverter.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer saw that resources appeared to be sufficient.

Reviewer 2:
The reviewer judged that the team has good resources to carry out the project.

Reviewer 3:
The reviewer decided that resources were sufficient for this project based on progress to date.

Reviewer 4:

The reviewer thought that it will be great if the project has had more internal resources rather than relying on external resources.

Cost-Effective Fabrication of High-Temperature Ceramic Capacitors for Power Inverters: Balu Balachandran (Argonne National Laboratory) - edt061

Presenter

Balu Balachandran, Argonne National Laboratory.

Reviewer Sample Size

A total of five reviewers evaluated this project.

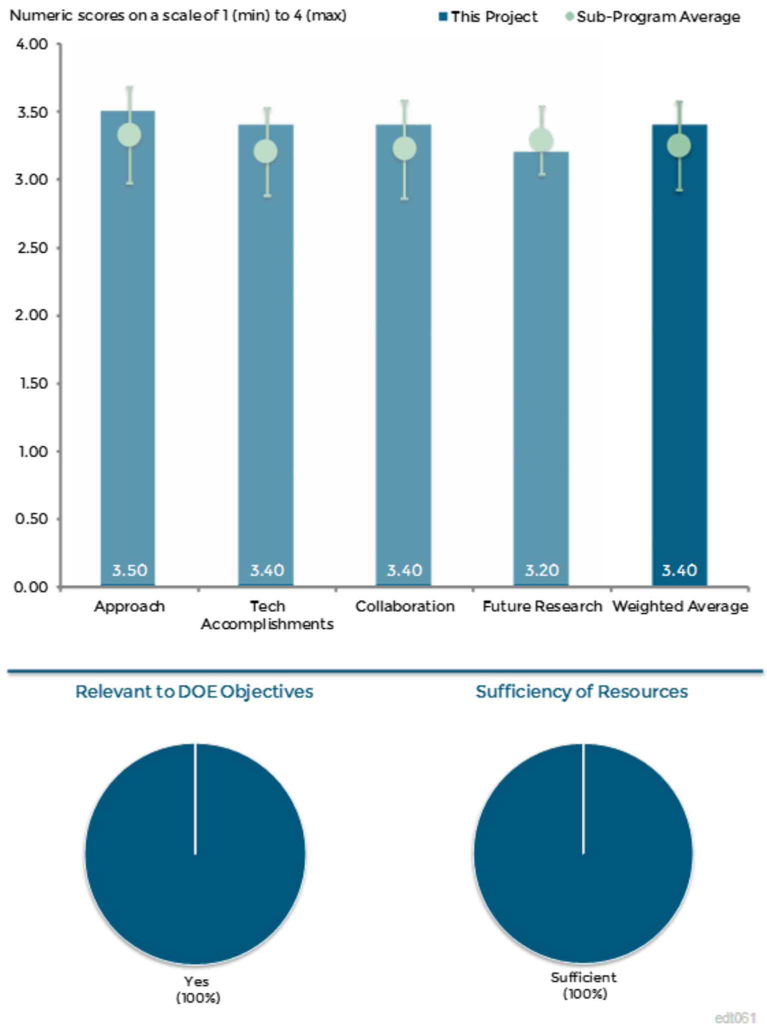

Figure 3-13 Cost-Effective Fabrication of High-Temperature Ceramic Capacitors for Power Inverters: Balu Balachandran (Argonne National Laboratory) - Electric Drive Technologies

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer considered the approach to be interesting and well executed. The concept for applying the lead lanthanum zirconate titanate (PLZT) film in a reel-to-reel process seems feasible.

Reviewer 2:

The reviewer saw a clear, sound approach that addresses the fundamental challenges that needed early resolution for this technology. This person liked the adoption of 3D printing the nozzles to quickly test nozzle designs.

Reviewer 3:

The reviewer summarized that this project addresses the need of a low-cost, high temperature, and smaller footprint capacitor for DC bus filtering applications in power converters and a team consisting of a Tier 1 inverter manufacturer (e.g. Delphi), leading capacitor designer (e.g., Sigma Tech), and university partner, makes it a winning team with a great potential for successful completion of the project.

This reviewer commended the PI and co-PIs for project work carried out so far, and encouraged the project team to look into peripheral applications of the developed technology, such as using developed material and technology for safety rated capacitor required for high temperature applications.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:
The reviewer thought the accomplishments thus far were impressive and were foundational for the successful continuation of the project, and thought the validated results from a potential Tier 1 user of the developed capacitors was good.

Reviewer 2:
The reviewer stated that the PLZT material is characterized over temperature, over frequency, over a voltage range including data for energy density and voltage withstand capability of PLZT material at room temperature and elevated temperatures. Manufacturing processes of PLZT base material is developed and could be scaled for mass manufacturing.

Reviewer 3:
The project appeared to the reviewer to be on track in terms of technical accomplishments. The capacitor technology appears to meet both temperature and dielectric constant targets. The reviewer recommended that the cost metric should be better defined and the cost performance of the technology should be more fully quantified as it matures.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
It reviewer observed that Argonne National Laboratory (ANL) has worked closely with Delphi in the validation of the material performance, and that ANL also appears to be working closely with possible manufacturers of the material.

Reviewer 2:
The reviewer determined that this project has a very good, complimentary team; the basic science and research from ANL; materials test, characterization, and science of processing from Penn State University; an experienced processor with knowledge to scale from Sigma Technologies; and a Tier 1 user of the product from Delphi. The reviewer would like have seen a real, traditional, high-volume film capacitor manufacturer on this team too just to keep it commercial

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer thought the next steps are logical, systematic steps and the plan for these steps seems considerate. Ultimately installing and testing as DC-link capacitors in a traction-sized inverter will be telling.

Reviewer 2:
The reviewer said the project team had thought out the next steps.

Reviewer 3:
The reviewer suggested that the investigators more seriously study the reliability of the thin film in relation to thermal cycling to verify that cracking does not occur over time.

Reviewer 4:
The reviewer reported that future research tasks are targeted prototyping, production, and commercialization of the high temperature, low cost, and high packaging density PLZT capacitor technology.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer said that high temperature, low cost capacitor technology is a critical element for future vehicle electronics (especially WBG devices).

Reviewer 2:

This reviewer agreed this project absolutely addresses the DOE objectives. Size, weight, and cost of power electronics are contributing to the slow up-take. Advanced DC link capacitors in traction inverters addresses all three of these items simultaneously.

Reviewer 3:

The reviewer maintained that the availability of high temperature, low cost, and high packaging density capacitor is a must for successful adoption of WBG power electronics, which aligns with the DOE EV Everywhere objectives.

Reviewer 4:

The reviewer reported that this project works on density, temperature rating, and cost.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said the project was well resourced in terms of labor, expertise, and funding.

Non-Rare Earth Motor Development: Tim Burress (Oak Ridge National Laboratory) - edt062

Presenter

Tim Burress, Oak Ridge National Laboratory.

Reviewer Sample Size

A total of five reviewers evaluated this project.

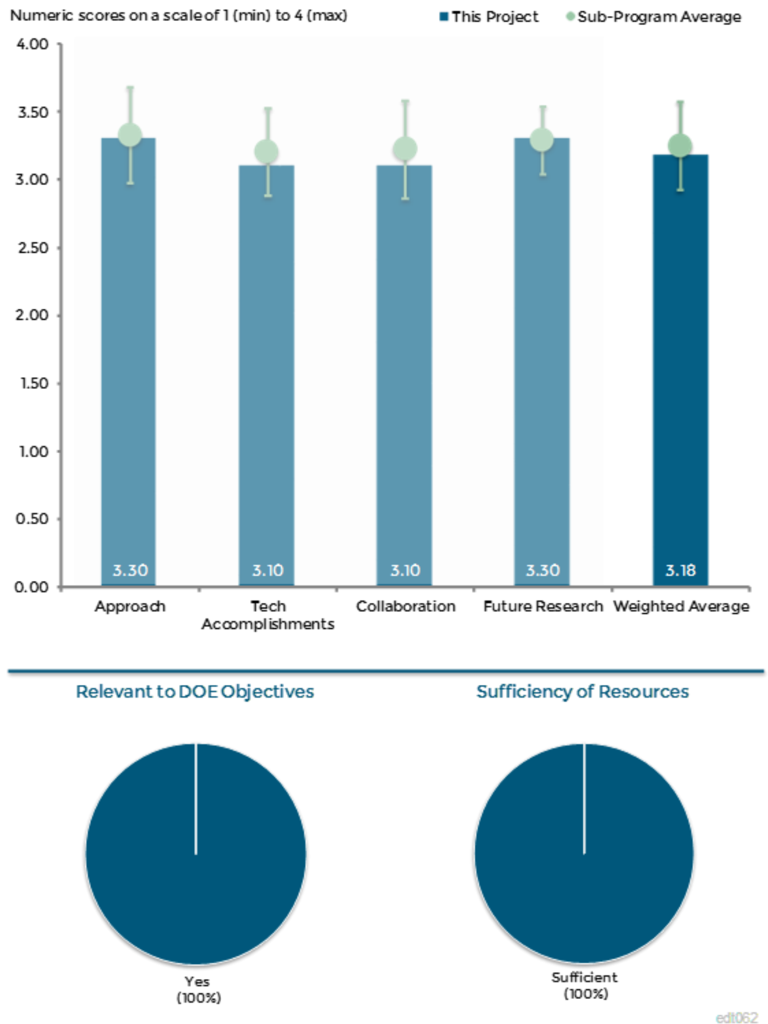

Figure 3-14 Non-Rare Earth Motor Development: Tim Burress (Oak Ridge National Laboratory) - Electric Drive Technologies

Question 1: Approach to performing the work–the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer thought the technical barriers were quite well defined and theoretical foundations are sound. This person said there seems to be some lack of integration with other efforts, in terms of coordinating with absolute end users, e.g. automotive and aerospace industry who could potentially benefit from the technology.

Reviewer 2:

This reviewer was of the opinion that the scope of the work is very broad but it is not clear how the various technology pieces complement each other, and also the improvement in performance is not very clear.

Reviewer 3:

The reviewer suggested the team try to tie together the disparate efforts being made in multiple directions within the program, and maybe pick the one or two most exciting/most promising technologies to work on.

The reviewer indicated that on the motor design effort, the team has a good approach of first trying to find by simulation motor designs that could meet DOE Electric Drive Technologies 2020 targets, then proceeding to fabricate motor. This could be made a standard requirement of all similar projects.

In general, though, this person thought that the machines being studied are extensions of well-known topologies, limited by the same design limits related to electrical and magnetic loading, and thermal and mechanical constraints. It appeared to this reviewer that the advances being made on the lamination steel and the modeling capability can help make fundamental improvements to machine technology. This person would recommend demonstrating this technology on an existing baseline design where apples-to-apples comparisons can be made, rather than confounding it with changes to machine topology. Future extensions of the program can then consider selecting an optimal machine topology for the new technology.

Reviewer 4:

The reviewer agreed that even without using RE materials, 2020 cost targets are challenging.

The reviewer advised more decision points to better focus the target area for study for maximum gains: materials, motor modeling accuracy, design process and optimization, high efficiency steel, impacts of residual stress in electric steels, down-select motor designs.

The reviewer thought the process of down-selection of a final motor configuration/design was a little unclear, but understands there will be optimization using the super computer and selection based heavily on cost and manufacturability. The approach was to develop alternative motors that do not use RE magnets. Modeling of soft magnetic materials and residual stress effects. Synchronous reluctance, NRE permanent magnet, brushless field excitation, or a combination of two or more of the above.

The reviewer believed that chemical vapor deposition to increase Si content in steels was innovative, new and highly beneficial if it turns out to be a cost effective process.

The reviewer identified using micro-magnetics modeling to simulate magnetic properties in regards to steel with residual stresses as a high value proposition, as there is currently no good method of modeling losses in magnetic steels, especially with residual stresses and anomalous loss.

The reviewer thought the project was broadly scoped, looking at modeling techniques, new materials, and new motor designs, and would be interested to see how it all comes together.

The reviewer said that the integration with other efforts showed good usage of industry and other laboratories, and that the plan for collaboration is very good.

Reviewer 5:

The reviewer pointed out that this project has very similar approach to the long running GE project, consisting of identification of more than 10 new motor concepts, and down-selection of promising candidates with more detailed design and prototypes. The reviewer declared that the most promising candidates in this project are brushless field excitation motors and the new type of synchronous reluctance motor. For GE the best candidates are flux switching dysprosium (Dy) free PM motor, spoke ferrite motor, and DC biased SRM. This person wondered how well these two projects are coordinated by DOE to ensure overall projects goals.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer indicated that work was about 38% complete, which is compatible (or better) with the total time span of the project, and that the desired focus at each year end has been clearly indicated with bar graph, and table showing various milestones.

Reviewer 2:

The reviewer reported that the ORNL synchronous reluctance motor has been completed and is on their dyno. Efforts to model magnetic effects from residual stresses have begun and appear promising. The reviewer thought this capability would be quite useful for better efficiency/loss prediction. It seemed to this person that although there is much to do in terms of modeling and assessing the other motor topologies, the team is on course with respect to the project plan.

Reviewer 3:

The reviewer saw that good progress had been made on the core loss mitigation, magnet modeling, and thermal management. The latter topics may have some overlap with other programs within the same office. The reviewer believed that there may be an opportunity to streamline research on these topics.

The reviewer also stated that advances made in the machine topology were not obvious, and it was not clear what the true innovations in the machine design are. Synchronous reluctance and brushless field excited motors have been studied extensively by others, but perhaps this team has come up something interesting that it is yet to share in public.

Reviewer 4:

The reviewer said that it was not clear whether the accomplishments are focused on new materials or new ways of processing/modeling materials or motor topologies. This has to be clarified and better well-defined.

Reviewer 5:

The reviewer pointed out that ORNL claims that the new motor concepts have similar performance compared to baseline 2010 Prius motor, but that the power and Torque curves on Slide 18 do not really confirm that claim. Also, the reviewer wondered if comparing the new concepts against 2010 Prius motor, which is now two generations old, was a good idea to design the future motor.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer said there is good collaboration between different institutions as well as various technology areas.

Reviewer 2:

The reviewer considered collaboration and coordination with various institutions, i.e., academia and industry, to be excellent. This reviewer believed that it would add more benefit if some coordination was also done with end users of the final product, e.g., automotive, aerospace, and other industries who use electric motors in a complete system.

Reviewer 3:

The reviewer saw that there was opportunity to collaborate with the other teams and maybe even broader collaborations with motor development teams to study the impact of the improved materials and thermal management techniques on a broad variety of motor types, and to compare their performance. Perhaps starting with the other teams developing motors with funding from the same program office.

Reviewer 4:

The reviewer reported that collaboration is to occur with other laboratories and industry, but that it was unclear how close or coordinated the effort is.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer expressed that localized characterization of laminations with regard to losses and stress would be the most interesting and useful outcome of this project.

Reviewer 2:

The reviewer thought the proposed future work seemed reasonable but it would be helpful to bring more clarity about the motor topologies evaluated and how the sown-selection will be performed.

Reviewer 3:

The reviewer concluded that the project is well planned, but listed a few additional issues that will add benefit: First, it may be important also to think ahead about how to recycle the materials at the end of the lifetime of the motors. Second, it would be beneficial if a comparison of the material properties of the proposed NRE versus the existing RE materials was provided. This comparison will help better understand the complete picture.

Third, manufacturing process for high volume production should also be thought ahead, because eventually that will be necessary. Fourth, more detailed references, in the form of patents, papers, etc., on existing work or SOA will be helpful.

Reviewer 4:

The reviewer said that while it may be too early to do for some of the technologies being pursued, the team should really try to quantify potential benefits of the different approaches being pursued, e.g., if iron losses were halved, what the impact on efficiency, thermal management, and rating are. The reviewer thought that it will be good to see how the advances in material technology would impact a more traditional induction motor design.

Reviewer 5:

The reviewer determined that the project has a broad scope and many potential paths for research and combining architectures, materials and modeling techniques. It was a little unclear to this reviewer what the decision points would be and what direction they would go at certain milestones, based on different scenarios of possible findings. The reviewer concluded that this may too be open-ended as well.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that the project is relevant because it explores technologies that can reduce dependence on RE materials as well as better modeling and hence prediction of machine performance

Reviewer 2:

The reviewer determined that the project focuses on low cost manufacturable motors, materials and design techniques, and that ultimately cost is the largest barrier to adoption of electrification, so the project definitely addresses this goal.

Reviewer 3:

The reviewer reported that the team has clearly focused on developing technology that will make electric/hybrid electric drivetrains more cost effective, which in turn should help with DOE's objective of petroleum displacement.

Reviewer 4:

The reviewer detailed that the project may not directly influence the petroleum displacement, because it is about replacement of the existing motors which use RE materials. If petroleum displacement in terms of vehicular fuel economy is considered, then it will not displace petroleum consumption. However, if the cost of getting RE material and its manufacturing process involve more petroleum compared to NRE materials, then it may save fuel in an indirect manner.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer thought that the resources would be sufficient for a program focused on the key innovations being made within the program, but that the team resources may be stretched if it proceeds full speed on all the fronts being currently explored.

Reviewer 2:

This reviewer decided that the resources seem sufficient based on the level of effort.

Reviewer 3:

The reviewer indicated that the resources at ORNL are vast, algorithm developers for new modeling techniques, super computers and testing capabilities all uniquely position them to do great things with this work.

Reviewer 4:

The reviewer determined that the resources indicated were reasonable.

Performance and Reliability of Bonded Interfaces for High-Temperature Packaging: Doug DeVoto (National Renewable Energy Laboratory) - edt063

Presenter

Doug DeVoto, National Renewable Energy Laboratory.

Reviewer Sample Size

A total of six reviewers evaluated this project.

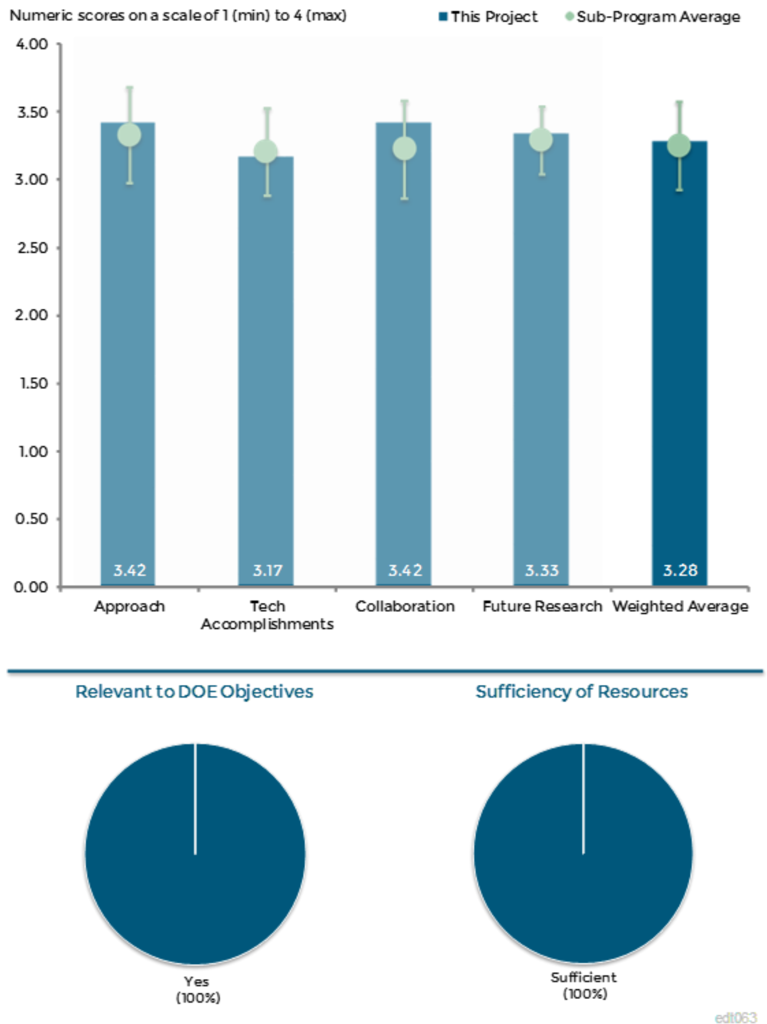

Figure 3-15 Performance and Reliability of Bonded Interfaces for High-Temperature Packaging: Doug DeVoto (National Renewable Energy Laboratory) - Electric Drive Technologies

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer considered this plan very clear and well-designed. Results from this project are helpful to all WBG projects expecting to take advantage of higher operating temperatures and will be operating at higher heat fluxes.

Reviewer 2:

The reviewer determined this was a well thought out and systematic approach.

Reviewer 3:

The reviewer reported that sintered-silver bonds are developed, thermal cycling is executed followed by inspection of sintered bonds, and data is collected data to develop failure models of sintered bond.

Reviewer 4:

The reviewer thought that using test coupons of different CTE's with thermal cycling to induce stress is a good idea, but pointed out that they had never seen an application where a square or rectangular device (die) is placed between round materials. The reviewer suggested perhaps a coupon with 90° corners would be more realistic to actual applications.

Reviewer 5:

The reviewer found a lack of systematic approach to address the performance optimization or reliability evaluation, and claimed that it was simply performance evaluation by testing, and therefore technical innovation was not significant.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:
The reviewer observed that the project is proceeding to plan and yielding results needed for next steps.

Reviewer 2:
This reviewer relayed that modeling updates are progressing, but wondered if a biased humidity test could be included with the thermal cycle tests to determine if the silver material will survive in a typical automotive environment (e.g., no dendrite). The reviewer recommended looking at Automotive Electronics Council (AEC) Q101 to see how packaged parts are qualified, and possibly adding some of those tests to testing efforts.

Reviewer 3:
The reviewer reported that the PI has established a procedure for material characterization and sintered silver bond degradation model. The reviewer thought that it could have been a great idea to change bond interface area and determine how CTE mismatch affects bond interface life and reliability if bind surface area changes by a factor of +0.2 to -0.2 from area considered in this project.

Reviewer 4:
The reviewer said the achievement in FY 2014 was not clearly shown in the presentation.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer indicated that a good set of companies are mentioned as collaborators including ORNL.

Reviewer 2:
This reviewer agreed that there was a well-rounded and represented team.

Reviewer 3:
The reviewer noted that the collaborations have increased from last year.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer considered the future work to well defined, but recommended that when looking at bond pad geometries to reduce stress, the project team should also add to the geometries how they may affect the thermal performance.

Reviewer 2:
The reviewer detailed that evaluation of low-pressure and no-pressure sintering is identified, which could be quite useful for industries, and that geometry area optimization is proposed.

Reviewer 3:
The reviewer’s only feedback is for the project team to also consider crack formation and propagation when heating/cooling is from the inside-out as a powered semiconductor would do between two CTE mismatched materials.

Reviewer 4:
This reviewer does not see a relevant amount of reliability work conducted or planned for the future.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer considered this as a companion project for all the WBG projects. The reviewer felt as though some of the WBG projects are focused on efficiency, size, weight, etc., but will not be able to take advantage of these items unless or until we all understand how to package semiconductors at these temperatures and heat fluxes. The reviewer concluded that this project helps us to understand those issues.

Reviewer 2:

The reviewer identified this as this project as providing the type of detailed understanding of materials in automotive application necessary to achieve cost reduction.

Reviewer 3:

The reviewer maintained that the proposed method could lower manufacturing costs of power converters and also it could raise reliability of electric drivetrain, which could lower cost of product and increase adoption of electric vehicles which could fulfill DOE objective of EV everywhere.

Reviewer 4:

The reviewer agreed that lowering the cost of power electronics and improving reliability helps to enable the market for power electronics.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that funding and people appear to be adequate to execute the project.

Electric Motor Thermal Management Research and Development: Kevin Bennion (National Renewable Energy Laboratory) - edt064

Presenter

Kevin Bennion, National Renewable Energy Laboratory.

Reviewer Sample Size

A total of seven reviewers evaluated this project.

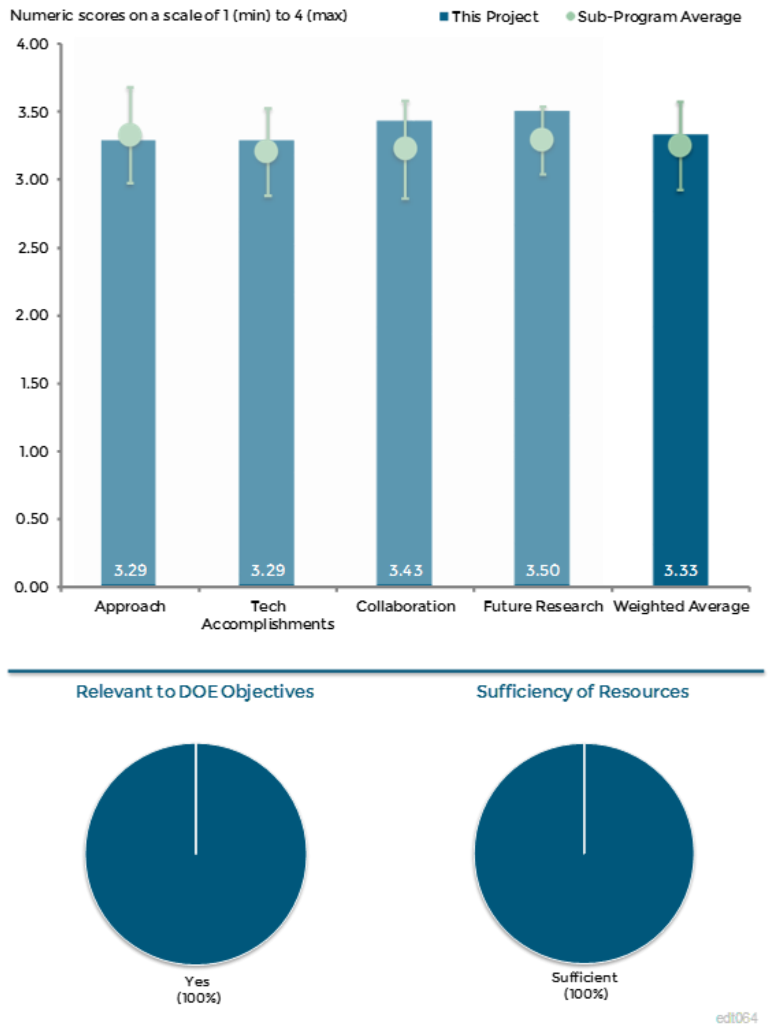

Figure 3-16 Electric Motor Thermal Management Research and Development: Kevin Bennion (National Renewable Energy Laboratory) - Electric Drive Technologies

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer indicated that the approach NREL is taking is very beneficial to industry, as data on the passive thermal circuit materials within motors is not widely known by manufacturers. The reviewer also thought that heat transfer coefficient is also very important to understand when making motor design tradeoffs and cooling method choices, and that the data NREL seeks in this set of experiments will be extremely valuable to the automotive motor community. The reviewer suggested that it would also be great to publish and present results along with data from other candidate cooling methods for motors.

Reviewer 2:

The reviewer declared it very systematic.

Reviewer 3:

The reviewer evaluated that the approach was good and was tackling several important areas, but recommended that more details that make the testing more realistic to what takes place in a real motor should be included.

Reviewer 4:

The reviewer believed that this is a very good general topic given the electromagnetic room available in some motors that can be taken advantage of with improved cooling. The team is taking a very reasonable approach to investigate this.

The reviewer thought that one interesting measure would be how much higher the peak load capability of the various electrical machine types is versus their steady state capability. Presumably the former is not thermally limited but the latter is. That will help quantify the benefits, and potentially help down-select machines in which the improvements in thermal performance would make the most impact. More details would of course have to be considered later because several factors are at play. It may be worth exploring this with the motor development partners the team is collaborating with.

Reviewer 5:

Reviewer 6:

The reviewer acknowledged that understanding thermal characteristic of the motor is quite complicated as it depends on the construction/packaging of the motor and type of winding structure, and that NREL is making good efforts in this area.

Reviewer 7:

The reviewer judged technical barriers to be correct, but perspectives are not very clearly described. For example, life has been indicated as a barrier. It was not clear to this reviewer in what sense the term life is used. It was also perceived that thermal management involves size and weight constraints on the overall system, which can be barriers as well.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer said that NREL has made significant progress in the areas of heat transfer coefficient measurement for jet impingement. Measurement of material properties for passive thermal circuit materials and thermal FEA modeling for motors. The reviewer expected the information sought will make that bank of data more accurate.

Reviewer 2:

The reviewer reported that work is about 38% complete, which is compatible with the total time span of the project. Although desired focus at each year end has been indicated, this reviewer thought a comparison chart or bar graph showing the desired milestone versus accomplishment would have been better to understand the status.

Reviewer 3:

The reviewer saw good progress but thought more quantitative results should be shared.

Reviewer 4:

The reviewer asked what the impact of end winding impingement cooling on coil hotspot temperature was, and speculated that this may be most beneficial to machines with temperature capability substantially more than automatic transmission fluid (ATF) temperature, e.g., induction motors with high temperature grade insulation. The reviewer thought the team may want to target such machines initially.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer declared that collaboration and coordination with various institutions are excellent, and noted that partnership with some end users have been clearly mentioned.

Reviewer 2:

It was clear to this reviewer that collaboration with other laboratories was occurring and the nature of the collaboration was also apparent. One example was the samples of windings from ORNL that simulated various gage sizes and fill factors. The reviewer anticipated that data from this experiment would be very interesting.

Reviewer 3:
The reviewer saw good collaboration between different institutions, but thought that more interaction with industry could be useful.

Reviewer 4:
The reviewer's analysis was that there is potential for increased collaboration, exchange of data/comparison with GE, the other group that is testing end winding impingement cooling. The reviewer suggested considering collaborating with universities as well, as they may be more open to sharing design information.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer was glad to see the future work includes the bar wound stator study because most of the leading OEMs manufacturing traction motors are now using this technology. So NREL's efforts in this direction will be effective utilization of the DOE funding.

Reviewer 2:
The reviewer believed the proposed work is relevant and addresses some of the current gaps.

Reviewer 3:
The reviewer reported that decision points for selecting approach and focus were laid out very clearly in the presentation, along with milestones and go/no-go items. This person thought it was a clearly thought out plan.

Reviewer 4:
The reviewer agreed that the project was well planned and the future plan is clearly defined.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer believed that thermal management is a key in terms of meeting the DOE targets for both the motor and power electronics

Reviewer 2:
The reviewer was of the opinion that improved thermal management is probably one of the biggest control knobs still available for significant increase in motor power density, assuming efficiency is still acceptable. This program can lead directly to improved electric powertrains that can help with petroleum displacement.

Reviewer 3:
The reviewer found that thermal considerations for motor design have a large effect on both cost and performance. Optimization of thermal performance and thermal management can have great effect.

Reviewer 4:
The reviewer stated that the work applies to both RE- and NRE- based motors. The reviewer speculated that if overall better thermal management leads to reduction of motor size while maintaining same power and efficiency, then it is likely to contribute to the objectives of petroleum displacement.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
This reviewer thought the resources are sufficient for the level effort

Reviewer 2:

The reviewer agreed that resources look sufficient.

Reviewer 3:

This reviewer's evaluation is that the capabilities for this experiment are easily met by the talent and resources at NREL.

Reviewer 4:

The reviewer concluded that resources indicated are reasonable.

Brushless and Permanent Magnet Free Wound Field Synchronous Motor (WFSM): David Ludois (University of Wisconsin-Madison) - edt065

Presenter

David Ludois, University of Wisconsin-Madison.

Reviewer Sample Size

A total of six reviewers evaluated this project.

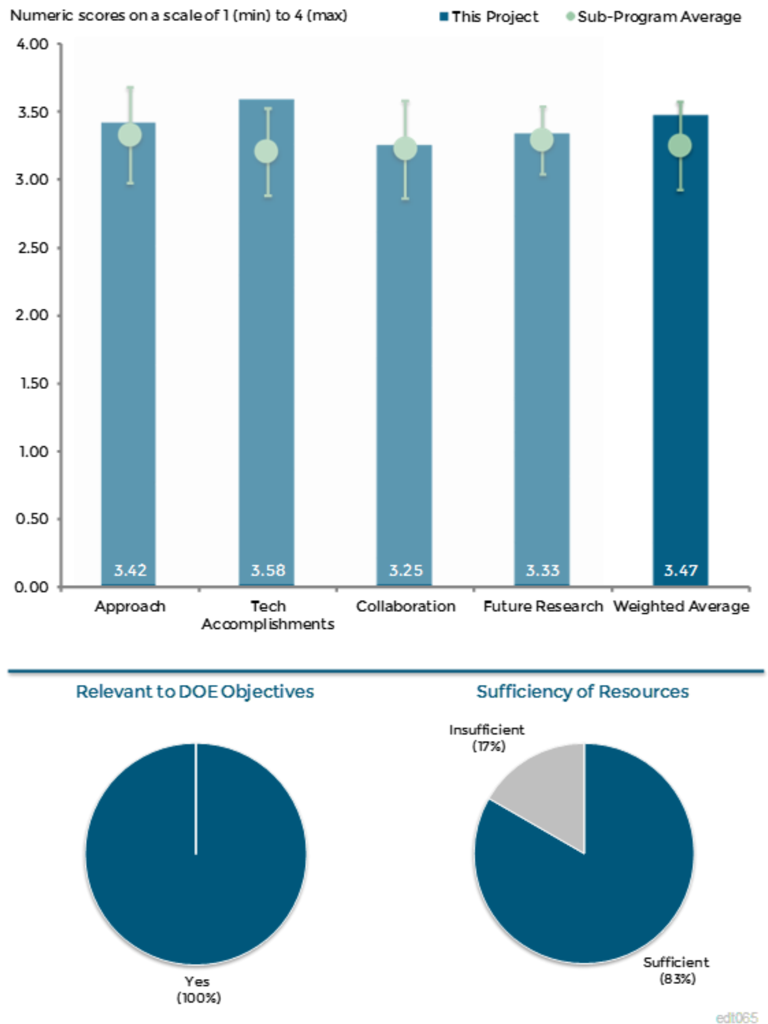

Figure 3-17 Brushless and Permanent Magnet Free Wound Field Synchronous Motor (WFSM): David Ludois (University of Wisconsin-Madison) - Electric Drive Technologies

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer said that, given the short time of the project, the authors have done a good job in presenting the capacitive coupling for brushless wound field synchronous motor.

Reviewer 2:

The reviewer judged the approach to develop a motor to eliminate the need for RE permanent magnets to be an important and relevant objective. The implementation for capacitive power transfer is interesting, and as the project moves forward it will be beneficial to quantify the efficiency and cost relative to the DOE targets. The reviewer asked how the efficiency and cost of the proposed design compare with the DOE targets.

Reviewer 3:

The reviewer found that the brushless capacitive transfer technique has some great advantages, but that there are several negatives associated with this approach, including the additional volume/reliability associated with the capacitive transfer plates, the cost/volume/reliability concerns associated with additional stationary circuitry and particularly the circuitry on the rotor. The reviewer stated that these are important issues to address for successful commercialization.

Reviewer 4:

The reviewer thought this project was especially refreshing to see because it was focused on one clear innovation. Whether this solves a real problem with wound field synchronous machines or not, the technology demonstrated here can open up new possibilities in electrical machine design. One concern this reviewer has is that it appears that a significant part of the effort is focused on demonstrating mature technology, at the risk of diluting efforts on the true innovation.

Reviewer 5:

The reviewer determined that technical barriers are more or less well defined, and that additional important barriers relate to the mechanical reliability of the capacitor coupling and also the amount of power transfer capability limits, without compromising safety. There seems to be some lack of integration with other efforts, in terms of coordinating with absolute end users, e.g., automotive and aerospace industry who could potentially benefit from the technology.

Reviewer 6:

The reviewer pointed out that the wound field synchronous motor (WFSM) has been used for many years in other markets, but adapting it to the automobile and truck market has merit. The reviewer thought that focusing on the capacitive power transfer (CPT) to enable WFSM relevance in the vehicle market was appropriate, and suggested that the packaging within the rotor to not impact overall motor length be a project mission.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer said that the team has made excellent progress in the first 6-9 months of the project, coming up with the motor and capacitive coupling designs that look viable.

Reviewer 2:

The reviewer said that, considering this is a new start, a significant amount of accomplishments is not expected, but that considerable progress was made on several fronts on this project. The reviewer reported that great detail was provided regarding the modeling approach, and that detailed performance and efficiency estimates from simulation will be timely for future presentations.

Reviewer 3:

The reviewer conveyed that the work progress indicated has been completed as per timeline, which is compatible with the total timespan of the project. The reviewer qualified, however, that although desired focus at each year end has been indicated in a table, a comparison chart or bar graph showing the desired milestone versus accomplishment would have been better to understand the status.

Reviewer 4:

The reviewer recounted that the project just started, but design progress on the CPT is good. The CPT concept has some challenges that were discussed. The run out of the disks relative to the stator and rotor must be minimal. The reviewer thought that relying on a film at relatively low speeds may be problematic. The reviewer additionally recommended that the end play of the rotor relative to the stator needs to be minimized. The bearing design/choices need to allow for very little end-play, otherwise the disks will collide. The concern of shaft end play was not discussed. The reviewer further conveyed that the magnetic center of the rotor relative to the stator needs to relatively precise, otherwise the fields will tend to pull the shaft in a direction that will lead to collision of the disks.

Reviewer 5:

The project appeared to the reviewer to have demonstrated the capacitive coupling technique using gap pads and work is underway to implement it on a rotor. Information related to the expected efficiency of the proposed capacitive coupling technique would be of interest. Also, the expected impact on the motor efficiency would be important. The reviewer thought it would be nice to include the input and output voltage and current of the proposed design. The presentation mentioned the advantages at higher speed operation, but does the speed of the rotor have any impact on the power transfer. The reviewer concluded that work appeared to be progressing on the design of the motor.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer thought the collaboration and coordination with various institutions (i.e., academia and industry), are excellent, but that it would add more benefit if some coordination was also done with end users of the final product (e.g., automotive, aerospace, and other industries) who use electric motors in a complete system.

Reviewer 2:

The reviewer observed that the collaboration between universities appears strong, but additional collaborations with a motor supplier could be a benefit as the project moves forward.

Reviewer 3:

The reviewer reported that the collaboration between the two universities is good, but the relative roles of the universities is not clear.

Reviewer 4:

The reviewer said that the University of Wisconsin and Illinois Tech appear to be working well together, but thought there may be room for improvement in outreach to other entities with more experience in brushless and more conventional wound field synchronous machines.

Reviewer 5:

The reviewer suggested that additional collaboration with suppliers or OEMs may be advantageous for facilitating the technology-to-market process, and getting feedback with regards to feasibility.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that the future work appears to focus on developing the capacitive power coupling and the motor design, and that the plan allows for iteration of the design in the next year of work.

Reviewer 2:

The reviewer related that future plans entail several prototypes, and near term prototyping will help identify challenges associated with various new components used in this approach, allowing mitigation strategies to be developed at an early stage of the project.

Reviewer 3:

This reviewer thought the team has a good plan for demonstrating the technology being proposed. It was not clear from the presentation whether an adequate plan is in place to qualify the highest risk components of the project, specifically the brushless power transfer, before integrating it within the whole motor. Also, this reviewer suggested that to increase chances of success, the program office may consider reducing the requirements on the whole motor demonstration so unnecessary risk is not taken on the more standard parts of the motor design and build.

The reviewer also thought it would be good to see a comparison of the proposed method with other approaches, quantifying wherever possible; e.g., size, weight, cost, reliability, maintenance cycles, etc.

Reviewer 4:

The reviewer decided the proposed plan follows a good path, as the CPT is by far the highest risk element of the project and good focus has been put on the development. The reviewer suggested that alternative concepts or other approaches be considered to minimize/manage project risk.

Reviewer 5:

The reviewer appraised the project as well planned, and added a few additional issues that will add benefit: One, additional important barriers relate to the mechanical reliability of the capacitor coupling and also the amount of power transfer capability limits, without compromising safety. Two, manufacturing process for high volume production should also be thought ahead, because eventually that will be necessary. In addition, the issue of complexity of manufacture due to rotary capacitor and rotor winding, should be considered, along with cost ramifications. Three, more detailed references (patents, papers etc.) on existing work will be helpful.

Reviewer 6:

The reviewer stated that direct comparison of the inductive and capacitive coupling for this type of motor in terms of performance, cost, packaging and manufacturability will be great to be included in the next update.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer reasoned that this project supports the DOE objectives to reduce petroleum because power dense and efficient motors that reduce the need for RE elements are important to reduce the cost of motors in vehicle applications.

Reviewer 2:

The reviewer reported that this project aims to develop alternatives to RE PM motors, and if successful, it will facilitate the electrification of powertrains by offering a motor design with more stable production cost.

Reviewer 3:

The reviewer reported it develops a low cost and power dense electric motor.

Reviewer 4:

Given that the key enabling technology within this program (the capacitive coupling) has possible applications even beyond brushless excitation of wound field synchronous machines, the reviewer believed that the project has potential to impact DOE objectives.

Reviewer 5:

The reviewer concluded that in the midterm to long-run it does meet DOE objectives, even though immediately it may not. Petroleum displacement may come about indirectly. It may not directly influence the petroleum displacement, because it is about replacement of the existing motors that use RE materials. If petroleum displacement in terms of vehicular fuel economy is considered, then it will not displace petroleum consumption. However, if the cost of getting RE material and its manufacturing process involves petroleum, then it may save fuel in an indirect manner.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer reported that the funding level is low and the project is benefiting by using low cost students to get the work done.

Reviewer 2:

The reviewer stated that compared to the other projects within the same program office, it looks like this team is promising significant effort (i.e., design optimization, motor build, and test) for relatively lower program dollars. It did not appear to the reviewer that the team has allowed for iterative steps building on lessons learned during hardware demonstration.

Reviewer 3:
The reviewer said the resources appear to be sufficient.

Reviewer 4:
The reviewer conveyed that resources indicated are reasonable.

Traction Drive Systems with Integrated Wireless Charging: Gui-Jia Su (Oak Ridge National Laboratory) - edt066

Presenter

Gui-Jia Su, Oak Ridge National Laboratory.

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

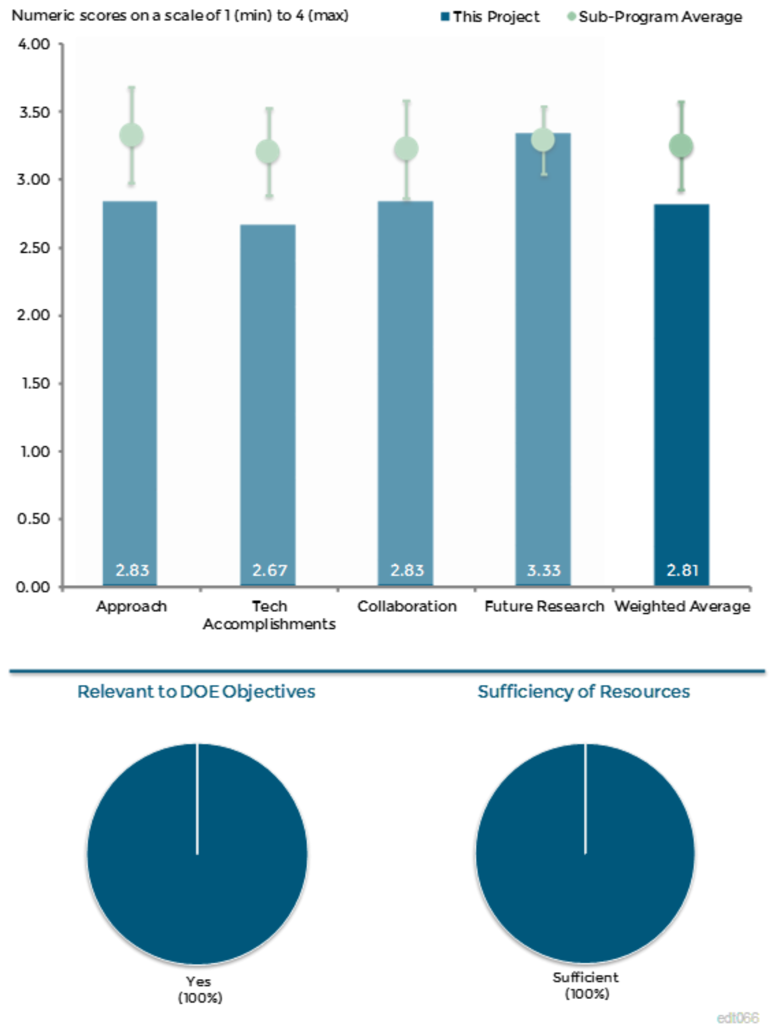

Figure 3-18 Traction Drive Systems with Integrated Wireless Charging: Gui-Jia Su (Oak Ridge National Laboratory) - Electric Drive Technologies

Reviewer 1:

The reviewer shared that although reduction of components (47%) is good, use of SiC and need for extensive infrastructure for inductive wireless charging may counterbalance the cost savings of the approach.

Reviewer 2:

This reviewer agreed with the approach to increase the efficiency of the wireless charging system through the use of WBG switches and improved coils and controls, but is not sure that integrating them within the traction electronics is the correct path. In the case of a PHEV the traction electronics may be located under hood where space is typically at a premium and any increase in size is an issue. Because the coils will be located under the vehicle the charging electronics may make more sense to be located near the pick-up coils or in the battery pack. The impact of integrating functions must be fully investigated to ensure that each individual function is not sub-optimized such as using the motor as part of the wireless charging function would probably eliminate the ability to charge while driving, which might be desirable in certain applications. The reviewer thought that combining the analog power module (APM) and charger in one unit is good as long as the charger does not impact the efficiency of the APM during motoring mode. The reviewer would suggest concentrating on that approach and let the traction system optimize itself, and asked if the ability to support bi-directional power flow from the charge function was a requirement.

Reviewer 3:

The reviewer recommended the project team consider other impacts to the system when integrating functions. Should look at life of components given new duty cycle.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer considered the progress to date to be very good for a new start building on past work. The optimized power factor for the resonant circuit is especially interesting and may have application elsewhere. The reviewer noticed that the efficiencies are provided for high loads but what happens at lower loads such as the more typical 30-40% 12 Volt loads in a vehicle. The second area of concern is using the motor neutral as this may not be as simple as thought, depending upon the motor winding process which may end up with the phase neutrals in different locations around the motor. The reviewer added that another issue is the cost of bringing another power lead out of a liquid filled motor/transmission combination, which requires a sealed connector arrangement. This reviewer concluded that the simulations look very good.

Reviewer 2:

The reviewer reported that the PI stated the literature review was completed and listed such as a major accomplishment, but did not present a single peer-reviewed publication reference. The reviewer suggested that the group recognize and reference previous related work from other groups and their own. The point of the literature review is to learn from previous research to guide the current research. This reviewer further pointed out that the PI stated that component and module models were built, but, no power quality numbers or harmonics were presented. The claim was made that power factor was high, and harmonics low, but no quantitative presentation of such was made.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer assessed that the team had a very good mix of component expertise which should supplement the circuit design expertise at ORNL, but did not see a vehicle integrator on the team, which will be necessary at some point to assist with integrating the system into a vehicle for demonstration purposes.

Reviewer 2:

The reviewer recognized that it may take some time to show integration and collaboration with partners, because this is a new start.

Reviewer 3:

The reviewer said it seemed that getting parts from the collaborators is most of what is being done, but did not have any information that shows real interaction with the collaborators is taking place.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer though the team had a reasonable and logical step by step plan.

Reviewer 2:

The reviewer believed the planned future work was appropriate if the concerns mentioned above in the Approach section are addressed. Starting with a 3.3 kW and progressing to 6.6 kW is a good plan. The reviewer asked if the intent is to build a 6.6 kW power stage or parallel 2 3.3kW stages, and if the impact on efficiency if the input power is limited to 1 kW or 3.3 kW.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer indicated that battery electric vehicles (BEVs) have potential to completely eliminate petroleum use, and that inductive charging may increase BEV market penetration and end use capabilities.

Reviewer 2:

The reviewer thought that a goal of improving the efficiency of wireless charging using improved coils, controls, and WBG devices is very relevant to the DOE goals but was not so sure that integrating them into the traction system is as relevant. That will be determined by the overall vehicle architecture.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer concluded that resources are sufficient but that it might be advantageous to add a vehicle integrator or at least have access to a couple of them.

Reviewer 2:

High-Efficiency High-Density GaN-Based 6.6 kW Bidirectional On-Board Charger for PEVs: Charles Zhu (Delta Products Corporation) - edt067

Presenter

Charles Zhu, Delta Products Corporation.

Reviewer Sample Size

A total of four reviewers evaluated this project.

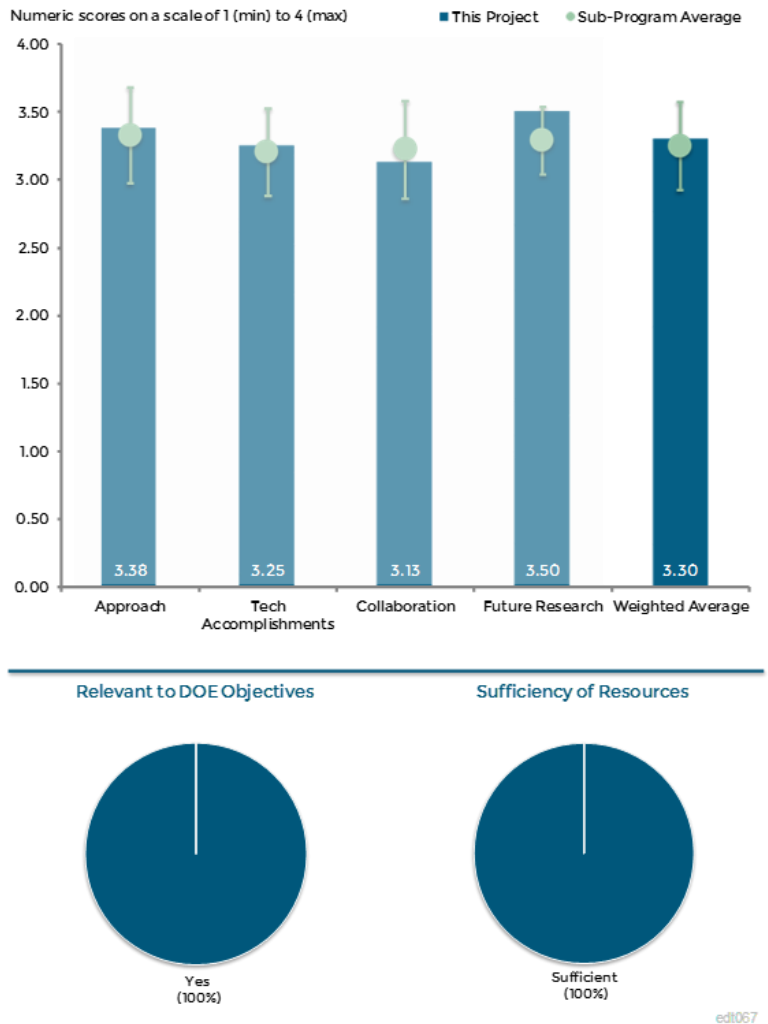

Figure 3-19 High-Efficiency High-Density GaN-Based 6.6 kW Bidirectional On-Board Charger for PEVs: Charles Zhu (Delta Products Corporation) - Electric Drive Technologies

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that this was a nice justification for the need and objectives of the program was presented, and thought that the presentation was a nice and brief technical description of the team's concept for integrating bi-directionality with on-board chargers (OBC) and reducing the number of switching devices was presented. The reviewer also thought it was a nice brief presentation of higher frequency benefits.

Reviewer 2:

The reviewer found a clear understanding of what is needed for the application and how to investigate.

Reviewer 3:

The reviewer reported that this is a new project that will be using GaN devices in a bidirectional on board charger. The approach is to reduce the module size thus increasing power density and increase efficiency. The approach plans to take advantage of the switching speed of GaN devices as well as the lack of need for a separate freewheeling diode, which should allow for fewer devices and smaller magnetics, both of which will reduce the size of the unit. The high speed switching ability of GaN will allow a reduction in the size of the magnetics and other passives with in the unit. The reviewer found this approach would be reasonable if the GaN devices are able to perform as specified. The selected cascade GaN switch demonstrated good performance in supplier testing is appropriate for this use. The topology selected by Center for Power Electronics Systems (CPES) is based on an existing sine squared charger that also used early GaN switches that did not meet expectations and limited the power of the charger. The reviewer thought the design had potential and did provide insight into the size reduction potential and the issues with finding magnetics capable of meeting the needs at higher switching speeds. Plan A is based on a known topology and should meet the performance goals assuming that the team can find magnetics/passives that will meet the requirements at high switching speeds and still meet the size requirements.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer summarized that the accomplishments in a short time appear to be quite good, both with the experimental equipment tested and topologies investigated, and requirements for better magnetic and capacitor components. This reviewer reported that part of the charger concept prototypes was already built and tested. Test results so far are, however, incompletely demonstrated and should include quantitative analyses of power factor, efficiency, and harmonics. The reviewer further observed that the project team has so far tested only up to 3.3 kW and 150 kHz, which is very far from the objective 6.6 kW and 0.3 - 1.0 MHz.

Reviewer 2:

The reviewer thought progress was outstanding for a new program. The reviewer summarized that waveforms from the prototype look good and the operational modes of the DC/DC stage look good. The investigation into magnetic material has started as well as initial characterization of the selected GaN device. The operating frequency of the prototype stages is lower than the desired 300 kHz but very good for an initial test. Past experience with both Delta and CPES leads the reviewer to believe that this project will continue to make good progress and will meet the goals. The prototype charger appears to be based on air cooling of the devices, which is possible with the low switching losses of the GaN devices as demonstrated by the Trasnphorm boost testing but the reviewer thought that liquid cooling may be more beneficial for the final product if a more compact design is the goal. What was not discussed is the interface to the grid when the charger is providing power to the grid. This reviewer was not sure that today’s charging standards define that mode or the control interface to be used. This may result in having to test the unit as a standalone DC/AC source or electric power takeoff (EPTO) to show the capability until the interface is defined.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer reported that this is a strong team in the areas of devices with Transphorm and circuit topologies and components with Delta and CPES. Fiat Chrysler Automobiles (FCA) brings vehicle integration experience. The results so far indicate that the technical members are working well together. The only item lacking is the interface to the grid interconnections which may be provided by FCA or another collaborator who has experience in supplying power to the grid. The reviewer believed that this is an industry opportunity that needs to be worked by the charger suppliers, vehicle OEMs, and utility companies to provide a standard interface if bi-directional chargers are to become a standard across the electric vehicle community.

Reviewer 2:

The reviewer said that because this is a new project not much collaboration was yet demonstrated, but expected this should improve in future years and must be better demonstrated in future years.

Reviewer 3:

The reviewer qualified that although understood Transphorm is key team member, and Infineon Si C7 superjunction MOSFET is key benchmark, it would be very interesting for the benchmark comparison to be expanded. The reviewer’s suggestions are as follows: One, Infineon C7 superjunction – benchmark; two, Transphorm 650V field-effect transistor (FET); three, GaN Systems 650V FET; four, Cree 900V SiC MOSFET; five, Rohm 650V SiC trench MOSFET. The reviewer said that these parts are all widely available in catalog distribution (Mouser, etc.), so should be easily obtained, measured, and evaluated for modest cost and effort. The reviewer expected the result would be a much clearer picture of the WBG supply chain impact to OBC.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer observed a good approach that is patterned after commercial development in the automotive industry was presented, and thought it was great.

Reviewer 2:
Other that institution collaboration, the reviewer thought that future research was very good.

Reviewer 3:
The reviewer found the proposed future research plan to be logical and well thought out. It continues the development of the device as well as the circuit topology allowing for optimization of both in parallel. The plan includes developing several versions of charger and switches as well as integrating with the vehicle and finally a commercialization plan to get this charger to the market. All of these items are required to successfully complete this task.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer concluded that more compact and bidirectional charging is helpful to reduce petroleum use and increase PHEV market penetration.

Reviewer 2:
The reviewer declared that clearly cheaper, more efficient, and more power dense on-board chargers will lower the cost of EV.

Reviewer 3:
The reviewer pointed out that this project is one of a few that are not directed at motors or inverters. The OBC is an integral part of a BEV or PHEV and a bi-directional charger brings added capability to the vehicle. An added benefit of this project is an opportunity to further the development of GaN switches at a more realistic power level than trying to support high current level inverters from the beginning. The reviewer anticipated that it will allow the development of driving circuits as well as magnetic components.

Reviewer 4:
The reviewer reported that this project addresses bi-directional need for vehicle and grid.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer found the team had adequate resources to meet the task at hand but may need to add a grid interface capability later.

Gate Driver Optimization for WBG Applications: Nance Ericson (Oak Ridge National Laboratory) - edt068

Presenter

Nance Ericson, Oak Ridge National Laboratory.

Reviewer Sample Size

A total of four reviewers evaluated this project.

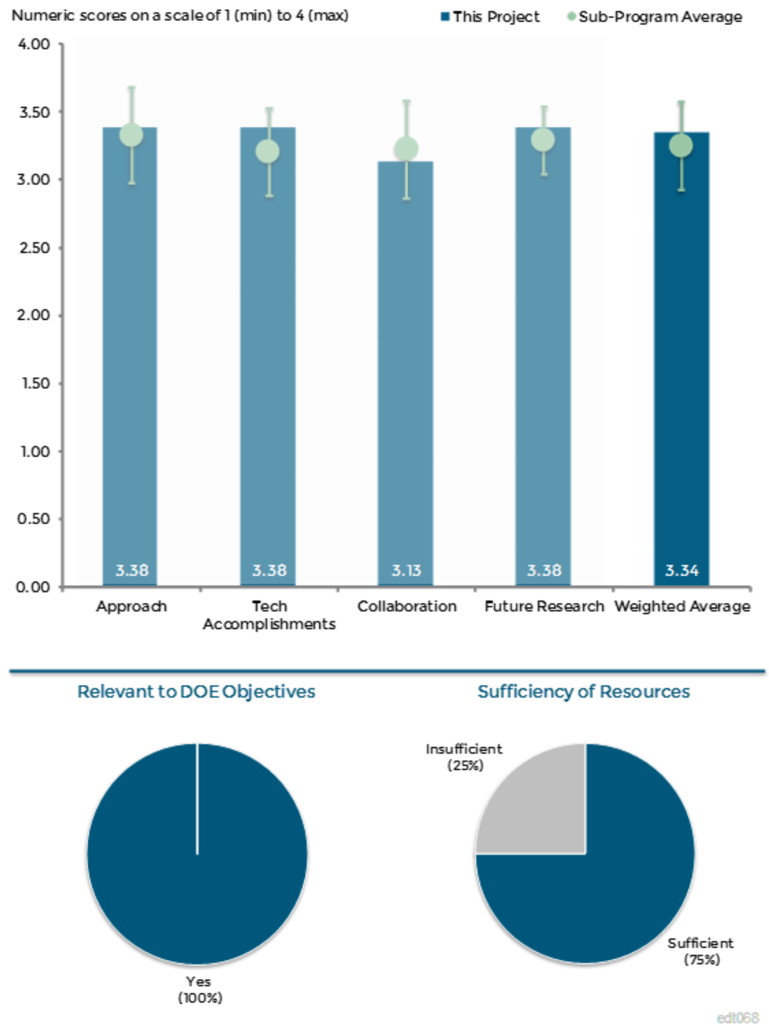

Figure 3-20 Gate Driver Optimization for WBG Applications: Nance Ericson (Oak Ridge National Laboratory) - Electric Drive Technologies

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer said that the development of a highly integrated gate drive capable of operating at high temperature and able to drive high power switching devices is sorely needed by inverter developers. While power modules have continued to shrink in size the gate drive circuitry has not and is now larger than the module driven in many cases. The goals listed in the presentation are a reasonable start at the requirements for a productized gate drive design. Building on work that has already been accomplished is good and allows the team to improve on that design where deemed necessary. This reviewer would like to see a review or solicitation added where the proposed functions are presented to various inverter implementers and comments requested with the intent of getting a broad set of requirements. Once this is done then the team can determine what makes sense to implement in a reasonably priced device. As mentioned above the requirements are a good start but fault modes need to be identified such as shoot through over current, shorts, bias supply issues, etc. The reviewer realizes that restraint needs to be applied to keep this chip from becoming the best gate drive device that nobody can afford.

Reviewer 2:

The reviewer agreed that a good justification for the research was presented.

Reviewer 3:

One concern this reviewer had with this project is what its aim is; for example, is it for the purpose of developing an understanding of what a systems integrator/designer needs to know or is it to get this gate driver produced. If to produce, then significant collaboration/partnerships would be needed for this to be successful.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer reported that previous research was noted as an accomplishment. The reviewer thought it was quite a nice review of the literature with sufficient references to previous research and peer-reviewed publications. The project nicely presented some initial model results with some undesirable oscillations (thus far) which the reviewer considered a technical challenge. The reviewer disclosed that the fundamental contribution of closed-loop gate drive techniques was not sufficiently characterized and described, and asked what the key technical contribution of this approach was.

Reviewer 2:

The reviewer thought technical progress to date was excellent with all of the previous work that has been done. The proposed design is reasonable but the reviewer thought that there needs to be some input from potential users of the device. This person was not sure that a desaturation function will catch all over current faults and the reaction time for short circuit on the WBG devices is not well understood/specified at present. The sensing method for di/dt needs to be investigated for potential impact on accuracy and efficiency of the system. Typical failure modes that systems have trouble with are phase to phase shorts in the motor (low occurrence) where the di/dt is controlled by the inductance of the loop. Progress in the area of modeling WBG devices is needed as was discovered by the team – this should help industry as a whole if good spice models can be created. The reviewer concluded that the team has a good list of the challenges ahead and a plan to attack them, which should lead to a successful project.

Reviewer 3:

The reviewer declared the project team was just starting, but were making good progress so far.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer said that it seemed like the collaboration and relationship with the University of Tennessee is sound and well-established as presented throughout.

Reviewer 2:

The reviewer saw very good involvement with SiC device manufacturers, and proactive outreach to them for models and data.

Reviewer 3:

The reviewer believed that the team had a good selection of members in CREE and the University of Tennessee, but a device manufacturer and an inverter supplier were missing. Perhaps it is too early in the process for manufacturing input but the reviewer would suggest talking to one who has a gate driver for Si in production if possible. This person thought that the team might be able to take advantage of the Tech Team for user input on gate drive functions. It appeared to the reviewer that the existing team members are working well together.

Reviewer 4:

The reviewer stated that the team needed to widen engagement to have commercial power electronics providers engaged.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer found this to be very necessary, important work. The point of high dv/dt and di/dt, is extremely salient given the strong performance of advanced SiC technology, and the very antiquated, high-inductance environments they often operate in. The reviewer concluded that users of SiC need to have good models, gate drivers, and tools to be able to utilize the new technology.

Reviewer 2:

The reviewer explained that the planned future work addresses previously discussed comments, which is good and perhaps occurs at a more appropriate time. This reviewer suggested that the engagement of OEMs should occur earlier rather than later but it need s to occur and is planned. The other tasks are in line with a well planned development process. One suggestion this reviewer had would be to add a review of the design requirements for the device prior to the fabrication of the first devices because it is an expensive process and the desire is to create a part that is as good as you get. The reviewer would also like to see an updated status of the critical assumptions and barrier as the project progresses.

Reviewer 3:

The reviewer recommended that the team should better show the path from prototype (use of off-shelf components for testing) to the integration of all of the technology into one integrated circuit.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer thought a slide, "Improved Gate Drive Methods Are for Full Realization of Reliable WBG-Based Systems," stated the relevance of this project. For the DOE objectives to be met, WBG devices will be needed and these systems must be as reliable if not better than today's Si based systems.

Reviewer 2:

The reviewer appraised that the technology is necessary for enabled WBG power devices that can increase EV use.

Reviewer 3:

The reviewer pointed out that the project enables adoption of SiC on a wide scale, which is needed to push down the costs and time to market of SiC implementation. Faster adoption of SiC will lower power losses, lower size and weight of power electronics, and reduce the use of petroleum fuels in hybrid electric vehicles.

Reviewer 4:

The reviewer confirmed that this is necessary for WBG introduction to yield system benefits.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said that it seemed like the team could use additional funding to bring the technology to commercial reality.

Reviewer 2:

The reviewer determined that the resources are sufficient at the present time but input will be required from other resources as the project progress.

Power Electronics Thermal Management Research and Development: Kevin Bennion (National Renewable Energy Laboratory) - edt069

Presenter

Kevin Bennion, National Renewable Energy Laboratory.

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

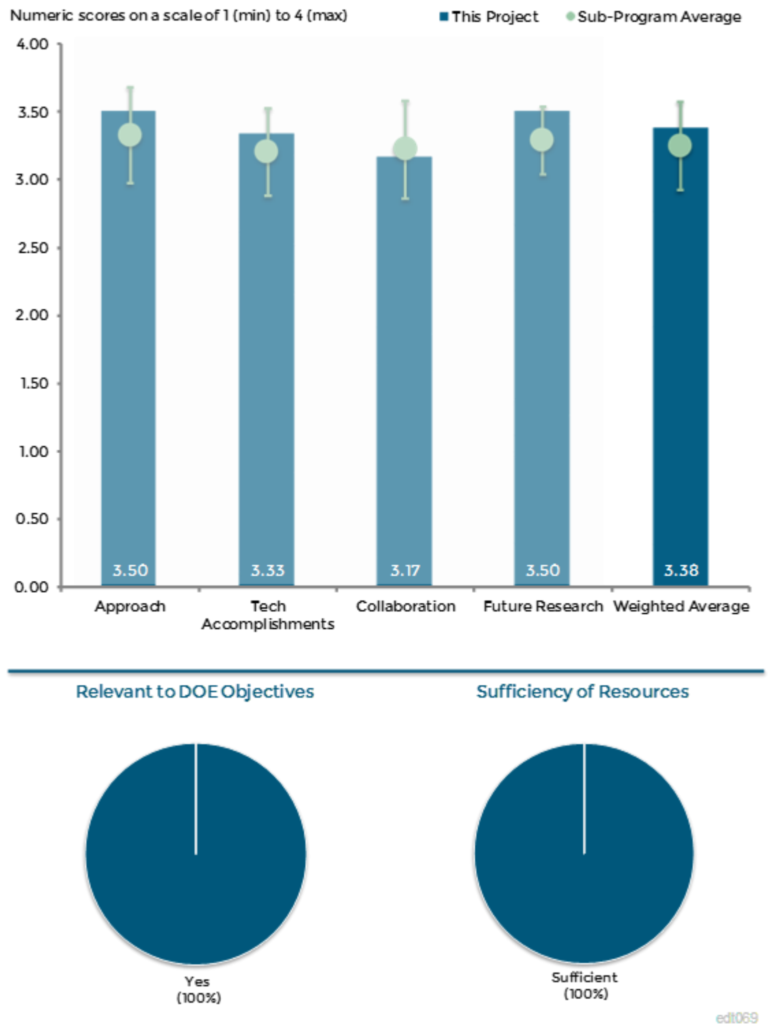

Figure 3-21 Power Electronics Thermal Management Research and Development: Kevin Bennion (National Renewable Energy Laboratory) - Electric Drive Technologies

Reviewer 1:

The reviewer stated that the project provides fundamental understandings necessary for increasing power density and reducing cost.

Reviewer 2:

The reviewer considered thermal management of power electronics to be an important R&D topic that should be supported by DOE. This reviewer found a nice simple introduction of the heat transfer challenges and the relevance of the project, but thought it would be nice to include the management of heat flows through other components of the complete system (not just the inverter module) and heat generation in other components. Complex and quite geometry, materials, and design specific – should span a range of technology and design options.

Reviewer 3:

The reviewer revealed that the objective is to examine methods to get heat out of devise and control heat paths for systems using high temperature devices: both Si and WBG. The reviewer thought the team had a very good approach covering both high temperature Si and the newer WBG devices that are more efficient but smaller, which creates higher flux paths that need to be dealt width. Intent is to examine existing high density high power units for methods that were used and for areas that could be improved or enhanced. Alternative methods of cooling will be investigated including costs and manufacturing methods as well as performance. High temperature experience is provided by APREI. Initial approach will be based on thermal modeling using computer-aided design (CAD) models followed by static FEA model with a plan to use CFD if required – good approach. Good understanding of and creation of data needed to effectively model the system. The team has recognized the potential impact on the rest of the system as well as how integration at the system level may impact the power device thermal performance. The reviewer concluded that there is high potential for advances in thermal design with this project.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer found that this is a new project with solid progress per their plan and approach. The presentation indicated a thorough understanding of a reasonable approach that would provide a high chance of success and that progress was being made along that plan. The reviewer judged the steps identified in the plan to be logical and reasonable and thought they should lead to a successful completion of the project. The plan includes looking at various thermal interface materials (TIMs) and thicknesses of them along with alternative cooling strategies such as air, different liquids, phase change materials, cold plate designs, etc., which is good but could take time and resources depending upon the availability and accuracy of existing models. The reviewer concluded that a reasonable amount of progress has been made to date but the next few months will determine if this project meets the reviewer's expectations.

Reviewer 2:

The reviewer stated that a literature search was listed as an accomplishment, but that Sato et al. 2011 was the only reference discussed along with some pictures from Tim Burress (ORNL) and Charlie King (NREL). This reviewer maintained that the literature review should be much more comprehensive.

The reviewer thought that selecting the Nissan LEAF inverter selected as a standard platform was okay and was presented as one of many that the work could apply to. The reviewer suggested the actual testing, simulation and evaluation of at least one other disparate system such as GM's Volt.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer reported that collaboration seems good, especially for a new start (2015) project. The reviewer expects that next year the team should be able to demonstrate how they actually worked together rather than just talking about getting CRADAs and non-disclosure agreements (NDAs) in place.

Reviewer 2:

The reviewer reported that the list of partners and team members shows a good mix of members with the appropriate skills and knowledge. At this point it is hard for this person to tell how well the team is working together but the plans and progress indicates that they are working well together. It is also encouraging to the reviewer to see that the team is actively trying to recruit new team members.

Reviewer 3:

The reviewer stated the team needs a vehicle manufacturer to ensure alignment with program objectives.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer found the project considers all aspects of the system and its thermal issues and was happy to finally see a comprehensive look at what is going on and methods of addressing issues.

Reviewer 2:

The reviewer stated that the remaining challenges and barriers have been defined and the future work should address these challenges/barriers to some degree. This person believes that the team is disciplined enough to continue down the planned approach and not get detoured or slowed by spending too much time on approaches that do not show promise when modeled. Considering transient behavior is very important as is fault tolerance to typical cooling system fault modes which should be added. The reviewer thought the plan for FY 2016 is good and it might be worthwhile to investigate means to move some of this into FY 2015 if possible without disturbing the team's progress.

Reviewer 3:

The reviewer suggested that the team should look at older inverters, not just new ones, because the grease degradation, increased Joule heating, corrosion, other worn parts, etc. may lead to significant heat management challenges that should be addressed.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer maintained that this project is extremely relevant to the goals of the DOE in that it will help produce a reliable product that is compact, efficient, and affordable. The thermal performance has a huge impact on the size, cost, and reliability of the inverter and this project is addressing methods to improve that. It will be up to the manufacturer to determine which approach to take but knowing what the performance will be will allow them to select the best approach for their product and one that will work in their manufacturing processes.

Reviewer 2:

The reviewer believes it is very important to consider and better design thermal management systems for inverter/converter systems and too little attention is typically paid to these very important aspects of working systems. This is a key enabling technology for introducing more EV technology.

Reviewer 3:

The reviewer cited fundamental understanding necessary for improving density and cost.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said the resources to date appear to be sufficient but more data on modeling support will be required to determine if it is actually sufficient.

Thermal Performance Benchmarking: Gilbert Moreno (National Renewable Energy Laboratory) - edt070

Presenter

Gilbert Moreno, National Renewable Energy Laboratory.

Reviewer Sample Size

A total of five reviewers evaluated this project.

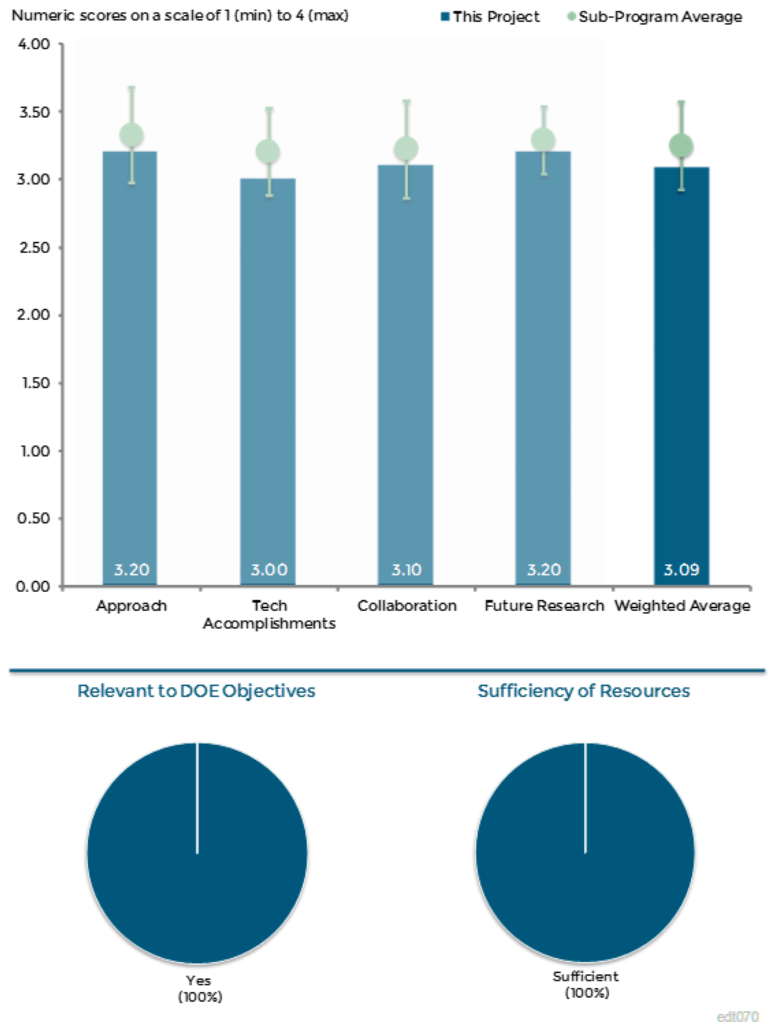

Figure 3-22 Thermal Performance Benchmarking: Gilbert Moreno (National Renewable Energy Laboratory) - Electric Drive Technologies

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer thought NREL and ORNL collaboration pathway with industries was appropriate, relevant and could address industry’s needs, and summarized that electric motor and power converter thermal management approach is outlined, and test platforms of Nissan LEAF motor, Honda Accord inverter, and auxiliary components are identified.

Reviewer 2:

The reviewer stated that thermal benchmarking sets a baseline for evaluating improvements in future designs

Reviewer 3:

The reviewer found it was early in the project but thought it seemed designed well and compliments the ORNL EV and HEV Benchmarking project (edt006).

Reviewer 4:

The reviewer thought a plan was needed to quantify or evaluate the test error compared to real operating conditions.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer found there was mostly planning with some early benchmarking performed so far because it is so early in the project, but that the team had accomplished what had been planned to accomplish.

Reviewer 2:
The reviewer saw that progress was being made, but was not sure how valuable data generated will be, because thermal data tends to be very specific for a particular solution.

Reviewer 3:
The reviewer reported that the project is a new start and work is progressing; the parts being evaluated are new parts but the vehicles they go into have been on the road for a couple of years. The reviewer wondered if it was possible to get some used parts with many miles on them to use for the benchmarking evaluations. The reviewer thought it would be easy to go back to create the ideal initial structure to see if the model predicts the current state of degradation of the used power electronics, and that would provide more validity to the model.

Reviewer 4:
The reviewer summarized that the motor is instrumented for development of a temperature map. Temperature map is used to develop thermal resistance data for various key points/locations in electric motor. Motor CAD drawing is developed. Only copper losses or thermal load due to copper losses are considered in the motor, when iron losses are also incepted, heat flow path could be altered resulting in different values of thermal resistances. This may need adjustment of thermal resistance map and values of thermal resistances.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer stated that ORNL and ANL are suggested as collaborators in this project.

Reviewer 2:
The reviewer held that some industry participation would be welcomed, but saw good communication between ORNL and NREL.

Reviewer 3:
The reviewer commented that the results of the benchmarking can be used by ORNL and ANL to evaluate improvements to the design that may be applicable to other applications.

Reviewer 4:
This reviewer suggested trying to engage an OEM.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer thought the next steps were logical, saw no real technical barriers, and said just execute.

Reviewer 2:
The reviewer reported that the method to identify performance of an oil cooled 2014 Honda Accord is suggested as one of the future research tasks.

Reviewer 3:
The reviewer relayed that the team was working to a plan to benchmark motors and inverter thermal performance.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer reasoned that this project has potential outcome to increase thermal performance of the electric motor and power converter, which supports DOE objectives.

Reviewer 2:

The reviewer maintained that improving the thermal performance of power electronics helps to identify ways to reduce the costs of power electronics, which helps to enable the market for EDVs which reduces our dependence on foreign oil.

Reviewer 3:

The reviewer thought that perhaps the project is not a direct contributor to reduced petroleum dependence because it is a benchmarking project. However, the reviewer predicted that it would indirectly contribute by assisting the industry in educating best (and worst) practices and new/novel techniques

Reviewer 4:

The reviewer saw that this project has value, but was concerned that thermal tends to be very specific to a system, and with the timeliness of the information generated.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer thought that human resources are adequate, but that the $200,000 funding seemed light for the work planned

Multi-Speed Range Electric Motor Research and Development: Lixin Tang (Oak Ridge National Laboratory) - edt071

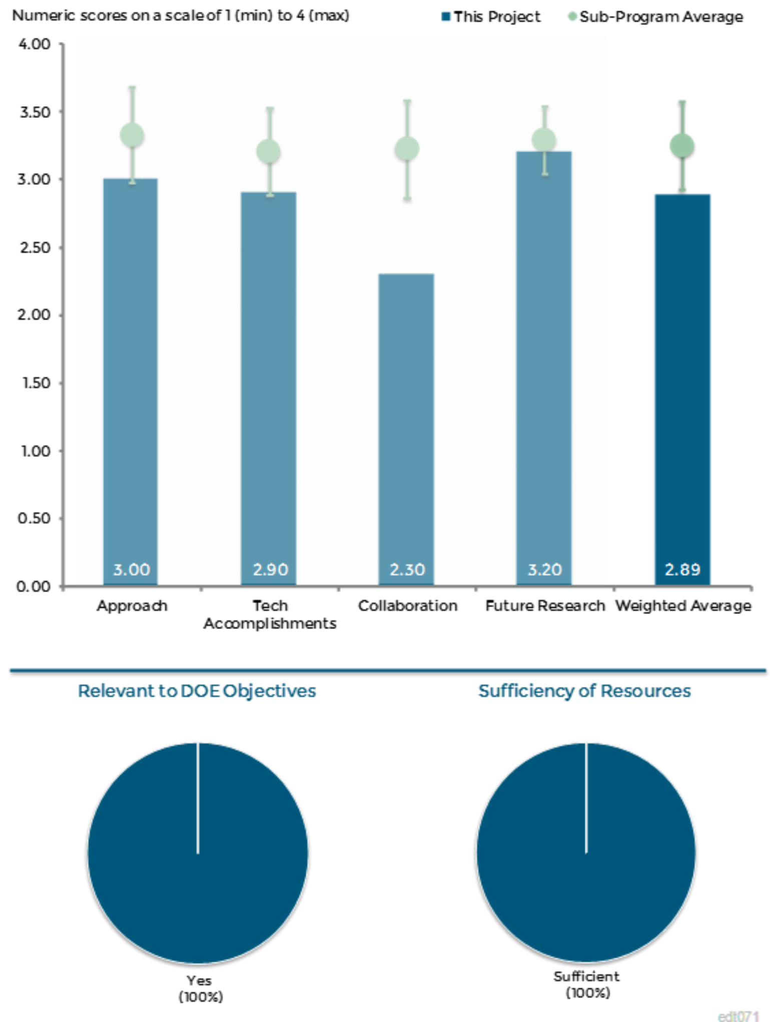

Figure 3-23 Multi-Speed Range Electric Motor Research and Development: Lixin Tang (Oak Ridge National Laboratory) - Electric Drive Technologies

Presenter

Lixin Tang, Oak Ridge National Laboratory.

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer predicted that the project has a high likelihood of success through use of purchasing motors with six wire outputs and solid state switches, and agreed that cost/complexity optimization through minimization of the number of solid state switches to accomplish the performance/efficiency goals while maintaining proper system protections is good.

Reviewer 2:

The reviewer stated that, generally, benefits of re-configurable windings are well known, but that the problem is the practical implementation of such concepts due to requirement of additional switches, torque interruptions and potential circulating current. The reviewer concluded that system level understanding is critical in evaluating the benefits of such concept.

Reviewer 3:

The reviewer concluded that technical barriers have been defined clearly. The barriers indicated in the beginning relate to consequence of not pursuing multi speed range motor R&D. Later on additional barriers related to extra complexity of the system have been detailed. All of these are relevant challenges. There seemed to this reviewer to be some lack of integration with other efforts, in terms of coordinating with absolute end users, e.g., automotive and aerospace industry who could potentially benefit from the technology. The reviewer concluded that the PI has indicated the intention to investigate such possibilities and given that it is a new project, it is understandable that this might take some time.

Reviewer 4:

The reviewer revealed that the high-level idea of changing motor speed range is not novel by itself, as pointed out by the PI, but there were not enough details about how the proposed approach is better than the state of the art.

Reviewer 5:

The reviewer found that the work reported showed the benefits of using reconfigurable windings for motor operation in wide speed range. This validates what is known in the art about the advantages of changing the winding configurations in series-parallel combinations to obtain constant torque from minimum to maximum speed without exceeding drive voltage limits. The challenge has been the trade-off of complexity and cost with the potential benefits. The reviewer reported that the team appeared to be focused on this challenge, but details of the new approach have not been shared.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer concluded that the technical accomplishments are very good to date. The reviewer found the expanded motor performance plots are very instructive on what can be accomplished through switching.

Reviewer 2:

The reviewer stated that the PI appears to have come up with a new concept to implement the winding reconfiguration with fewer switches, which may make the trade-off between benefits and added complexity/cost more favorable. However, the new concept is not described in the poster/uploaded material, nor shared during the poster presentation making assessment of the technical accomplishments hard to do.

Reviewer 3:

The reviewer reported that work is about 17% complete, which is reasonable in terms of the total time span of the project, given that the work was started in FY 2015.

Reviewer 4:

The reviewer found the project hard to judge because the project is new and aside from some high-level simulations, there were not enough details

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer reported a new project and no partners at the moment.

Reviewer 2:

The reviewer said that it does not look like any collaboration has been set up yet. It would be useful to reach out to an industry partner to understand relative costs of motor, inverter, and the switches needed for the proposed concept in order to perform a thorough trade-off of study.

Reviewer 3:

The reviewer pointed out that this is a small project. While the grade is poor, this person suggested that it remain a focused small project, otherwise the funding and scope should be revisited.

Reviewer 4:

The reviewer suggested that collaboration and coordination with various institutions, i.e., academia and industry, could be further extended. In particular, it would add more benefit if some coordination was also done with end users of the final product, e.g. automotive, aerospace, and other industries, who use electric motors in a complete system. Because this is new project, the reviewer understood that further collaboration will take some additional time to be in place.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer saw good proposed future work but more details about the approach are needed.

Reviewer 2:

The reviewer found the future plan to be satisfactory, but encouraged the team to also include a more rigorous benefit/cost analysis of the whole system, and to learn from past efforts by others.

The reviewer recommended that the team select a real baseline design to use as a benchmark and compare costs of implementing the new approach, with the new switches and any added costs to the motor in bringing more leads out of the motor to where the new switches will be mounted. Share a comparison to alternate system level approaches.

Reviewer 3:

The reviewer thought the project was well planned, but listed a few additional issues which will add benefit: One, the project will be very beneficial towards overall system efficiency increase. System level studies are very important and the effort is highly commended for that. Two, exact methodology for multi-speed range is not clearly indicated. It appears that PI has some patents etc. in the process, which might not allow at this time to describe details. Three, more detailed references, such as patents, papers etc., on existing work will be helpful, although some patents have been cited.

Reviewer 4:

The reviewer thought the proposed future scope should take the project to a paper and/or patent application.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer reasoned that the project enables much lower cost motor topologies such as induction to gain more relevance in EVs, HEVs, and PHEVs by dramatically increasing the motor's performance/efficiency curve.

Reviewer 2:

The reviewer clarified that the project relates to system level efficiency increase, and will therefore lead to better fuel efficiency and hence lead to the objectives of petroleum displacement.

Reviewer 3:

The reviewer said that if successful, increasing the efficiency over the drive cycle is important to meet the DOE targets

Reviewer 4:

The reviewer speculated that if successful, the team would have developed a motor-drive system that is better suited for a wide speed range without compromising on performance.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

This reviewer thought the resources are sufficient for the level of effort

Reviewer 2:

The reviewer found the resources indicated to be reasonable.

Reviewer 3:

The reviewer stated that, provided that the scope does not change, the funding is sufficient.

30 kW Modular DC-DC System using Superjunction MOSFETs: Robert Erickson (University of Colorado) - edt072

Presenter

Robert Erickson, University of Colorado.

Reviewer Sample Size

A total of six reviewers evaluated this project.

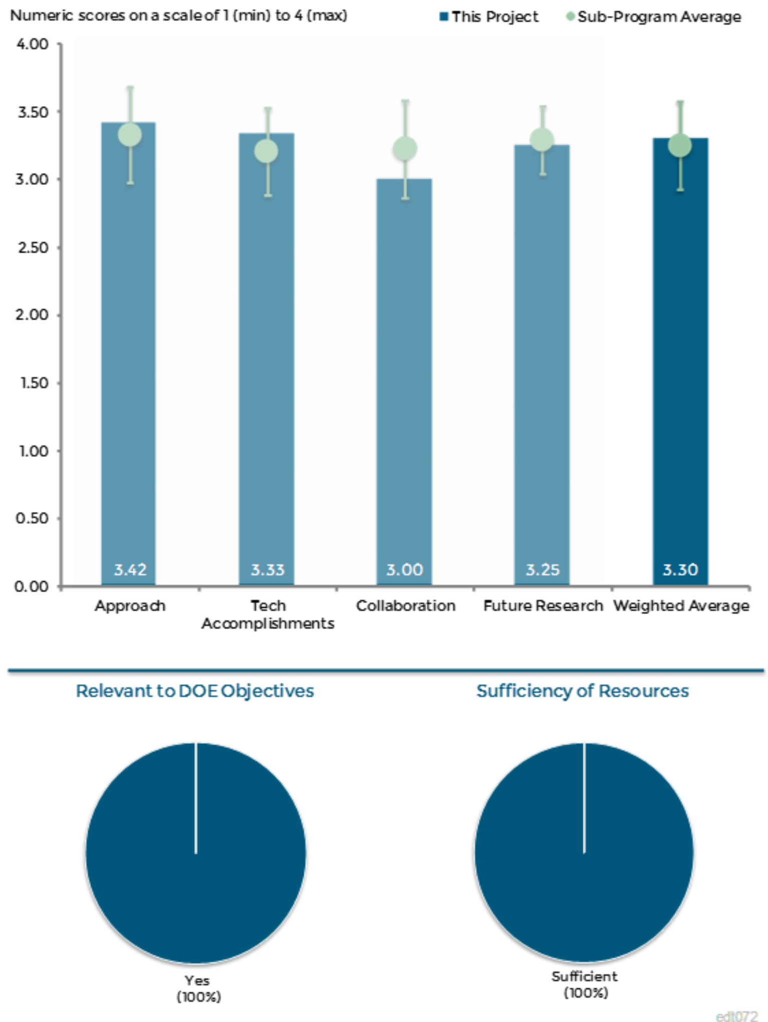

Figure 3-24 30 kW Modular DC-DC System using Superjunction MOSFETs: Robert Erickson (University of Colorado) - Electric Drive Technologies

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer thought the proposed architecture appears to have great potential, and was interested in seeing the system implemented in as-built hardware.

Reviewer 2:

The reviewer said that the approach is thoughtful and unique compared to others the reviewer has seen done.

Reviewer 3:

The reviewer considered this a thoughtful approach and a well-designed project, and stated that the goals are clear and objectively evaluable.

Reviewer 4:

The reviewer reported the project is very focused on a high efficiency DC-DC converter(s) with integrated charger. The reviewer declared it was a novel approach.

Reviewer 5:

The reviewer relayed that a composite converter topology is planned to be investigated to assess advantages such as efficiency improvements, film capacitor size reduction, and on-board charger size reduction.

Reviewer 6:

The reviewer thought the proposed approach (Buck + DCX) seemed to require more silicon switches and magnetics, which would contradict the high power density design.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer said that for this new start project the proposed architecture simulation results are encouraging.

Reviewer 2:

The reviewer agreed that this was a good start with lots of earlier simulation results looking good.

Reviewer 3:

The reviewer would be interested to see what the other considered topologies were and their related efficiencies, because the PIs commented that four architectures were considered, and the team settled on the presented approach.

Reviewer 4:

The reviewer reported that output power versus efficiency curve was obtained and an operating regime of DC bus voltage for maximum efficiency was identified.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer thought the roles of the various partners seemed well defined.

Reviewer 2:

The reviewer maintained that the existing project partnerships and collaborators were good, but that the team would be stronger with a systems integrator or OEM because the ultimate results will manifest themselves only through systems (drive-cycle) comparisons

Reviewer 3:

The reviewer reported that APEI is subcontractor for WBG power devices and APEI module picture is shown in the report. GE as SiC MOSFET supplier and Infineon as GaN FETs.

Reviewer 4:

The reviewer suggested that it would be useful to have a Tier 1 or OEM involved to evaluate the work and look at the economics of the approach as well as the overhead of the control strategies that would be involved with this system. The reviewer thought that from the technical side collaboration and coordination was excellent.

Reviewer 5:

The reviewer thought the team really needs a vehicle manufacture and national laboratories involved.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer found it to be well focused on the technical barriers

Reviewer 2:

This reviewer was looking forward to seeing the hardware.

Reviewer 3:

The reviewer judged the remainder of project to be well architected. The reviewer was not sure about the on-board charger relevance to the program, but considered it a bonus add-on.

Reviewer 4:
This reviewer reported that key tasks for future research are proposed.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer determined that the efficiency increase and size and weight reductions are aligned with DOE-APEEM targets

Reviewer 2:
The reviewer thought it addresses how to optimize best for efficiency.

Reviewer 3:
This reviewer found this approach helps to lower the cost of EDV power electronics, which helps to enable the markets for EDVs, which reduces our dependence on foreign oil.

Reviewer 4:
The reviewer resolved that this was a novel approach to support DOE objectives.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer thought resources were sufficient for the technical barriers, but that they may need some help from a Tier 1 or OEM for the cost targets.

Reviewer 2:
The reviewer agreed that resources and funding appeared sufficient

Evaluation of an APEI 88 kW SiC Inverter with Next-Generation Cree 900 V SiC MOSFET Technology for Ford Automotive Systems: Jeffrey Casady (Cree, Inc.) - edt073

Presenter

Jeffrey Casady, Cree, Inc.

Reviewer Sample Size

A total of six reviewers evaluated this project.

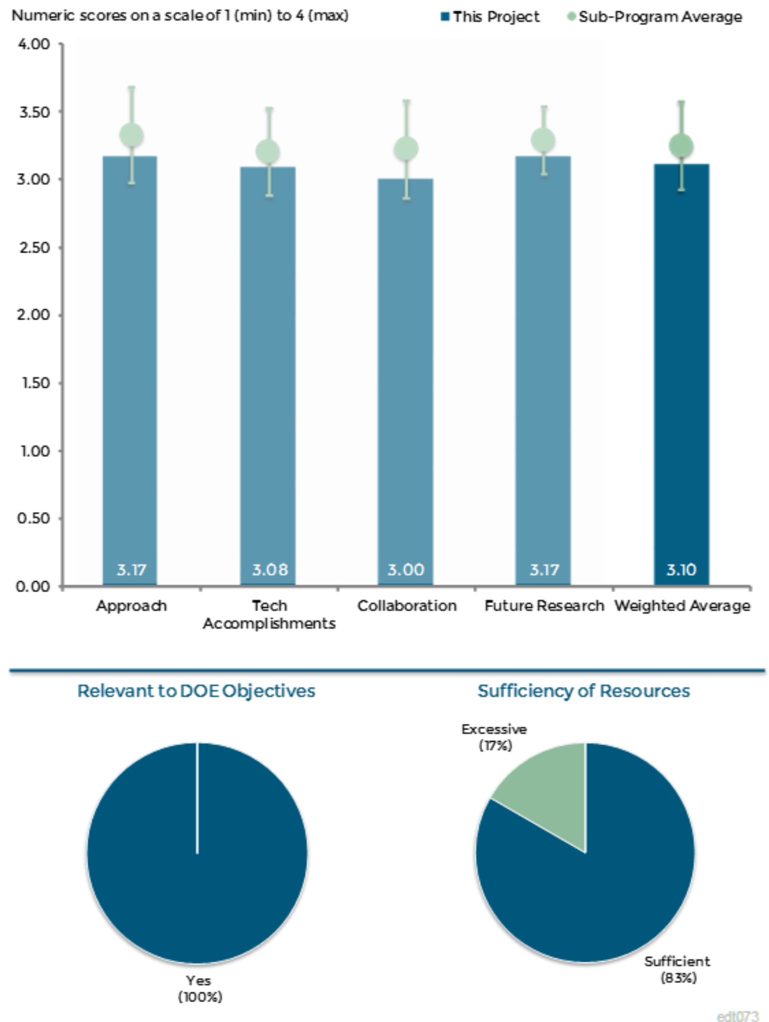

Figure 3-25 Evaluation of an APEI 88 kW SiC Inverter with Next-Generation Cree 900 V SiC MOSFET Technology for Ford Automotive Systems: Jeffrey Casady (Cree, Inc.) - Electric Drive Technologies

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer thought the objectives (i.e., AEC Q101 qualification) and approach appeared reasonable.

Reviewer 2:

The reviewer determined that the project goals were clearly based on the DOE targets, although the impact of the project seemed slightly limited. It looked to the reviewer like a key contribution is to drive down cost, but that further evaluation of the approach depends on the system architecture moving forward.

Reviewer 3:

The reviewer reported that Cree has a plan to enable and qualify their SiC MOSFET, in a TO-247 package, for future automotive applications. There is a plan to qualify the part in a module but no details are given; the reviewer asked if that detail could be disclosed.

Reviewer 4:

The reviewer relayed that project tasks are focused for design and development of 900V SiC MOSFET followed by development of 900V SiC half bridge and then demo of these devices in 88kW traction drive.

Reviewer 5:

The reviewer was not sure if this is appropriate work for DOE, because it seemed to be just about qualifying and demonstrating a part.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:
It appeared to the reviewer that the device is ready for the next stage in terms of packaging and device integration. Further evaluation of the results depends on the architecture and system performance moving forward. The reviewer asked about how, specifically, the device design impacts the projected cost target.

Reviewer 2:
The reviewer found that new start test data on the die is becoming available, and that multiple iterations of the die seem to be planned.

Reviewer 3:
The reviewer considered this to be adequate for this early in the project.

Reviewer 4:
The reviewer reported that RDS on resistance versus temperature data is characterized. Energy loss data shows that as compared to Silicon MOSFET, SiC MOSFET is 4 times better at 25°C and 6 times better at 150°C. This proves advantage of WBG material and encourages designers to use this material in power converter designs.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer assessed that the roles of the various project partners were clear.

Reviewer 2:
The reviewer reported that the implication was OEMs are evaluating inverters that are using Cree's MOSFET for future inverter projects.

Reviewer 3:
The partners on this project are what the reviewer would have wanted to see; semiconductor, packaging, and OEM. This reviewer was not sure how well they are working together.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer determined that the path forward seemed clear, although the details of the final system application are somewhat limited. The reviewer thought that early estimations of the projected cost of the system will be beneficial in determining the effectiveness of the proposed path.

Reviewer 2:
The reviewer reported that there is a test plan for the chip, the chip in packages, and the packages in inverters.

Reviewer 3:
The reviewer revealed that a set of tasks are proposed as future research.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer ascertained that lowering the cost, size and weight of automotive power electronics helps to enable the markets for EDVs, which helps to reduce our dependence on foreign oil.

Reviewer 2:

The reviewer resolved that all of the WBG projects have the potential to lower our dependency on petroleum. These projects have high risk, high cost development, and high reward potential.

Reviewer 3:

The reviewer judged that the objectives are aligned to achieve DOE APEEM targets

Reviewer 4:

The reviewer stated that SiC devices are more efficient and if qualified for automotive should help address DOE targets.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer was unsure about human resource sufficiency, but said the funding appeared to be more than adequate to accomplish the project goals.

Acronyms and Abbreviations

Acronym	Definition
3-D	Three-dimensional
AEC	Automotive Electronics Council
Al	Aluminum
AMR	Annual Merit Review
ANL	Argonne National Laboratory
APEEM	Advanced Power Electronics and Electrical Machines
APM	Analog power module
ATF	Automatic transmission fluid
BIM	Bonded interface material
CAD	Computer-aided design
CAFE	Corporate average fuel economy
CFD	Computational fluid dynamics
Co	Cobalt
CO2	Carbon dioxide
CPES	Center for Power Electronics Systems
CPT	Capacitive power transfer
CTE	Coefficient of thermal expansion
CY	Calendar year
DBC	Direct bonded copper
DC	Direct current
DOE	Department of Energy
Dy	Dysprosium
EDV	Electric Drive Vehicle
EETT	Electrical and Electronics Technical Team
EMC	Electromagnetic compatibility
EMI	Electromagnetic interference

EPTO	Electric power takeoff
ESL	Equivalent series inductance
ESR	Equivalent series resistance
EU	European Union
EV	Electric Vehicle
Fe	Iron
FEA	Finite element analysis
FET	Field-effect transistor
FOA	Funding Opportunity Announcement
FY	Fiscal year
GaN	Gallium Nitride
GE	General Electric
GM	General Motors
HcJ	Thermal coefficient of coercive force
HEV	Hybrid electric vehicle
HV	High-voltage
IGBT	Insulated-gate bipolar transistors
IPM	Integrated permanent magnet
ISMG	integrated starter motor generators
kW	Kilowatt
kV	Kilovolt
MGOe	Megagauss-oersteds
MLCC	Multilayer ceramic capacitor
MOSFET	Metal–oxide–semiconductor field-effect transistor
MPG	Miles per gallon
MPGe	Miles per gallon-electric
Nd	Neodymium
Ni	Nickel

NRE	Non-rare earth
NREL	National Renewable Energy Laboratory
OBC	On-board charger
Oe	Oersteds
OEM	Original Equipment Manufacturer
ORNL	Oak Ridge National Laboratory
PBA	Planar bond-all
PCB	Printed circuit boards
PEI	Polyetherimide
PEV	Plug-in electric vehicle
PHEV	Plug-in hybrid electric vehicle
PI	Principal investigator
PLZT	Lead lanthanum zirconate titanate
PM	Permanent magnet
PML	Polymer-multi-layer
PMSM	Permanent magnet synchronous motor
R&D	Research and development
RE	Rare earth
RPM	Rotations per minute
Si	Silicon
SiC	Silicon carbon
SOA	State of the art
TIM	Thermal interface materials
V	Volt
VTO	Vehicle Technologies Office
WBG	Wide bandgap
WFSM	Wound field synchronous motor
xEV	Electric vehicle (all configurations)

Zn	Zinc

4. Advanced Combustion Engines

Improving the efficiency of internal combustion engines is one of the most promising and cost-effective near- to mid-term approaches to increasing highway vehicles' fuel economy. The U.S. Department of Energy (DOE) Vehicle Technologies Office's (VTO) research and development activities address critical barriers to commercializing higher efficiency, very low emissions advanced internal combustion engines for passenger and commercial vehicles. This technology has great potential to reduce U.S. petroleum consumption, resulting in greater economic, environmental, and energy security.

Already offering outstanding drivability and reliability to over 230 million passenger vehicles, internal combustion engines have the potential to become substantially more efficient. Initial results from laboratory engine tests indicate that passenger vehicle fuel economy can be improved by more than 50%, and some vehicle simulation models estimate potential improvements of up to 75%. Advanced combustion engines can utilize renewable fuels, and when combined with hybrid electric powertrains could yield further reductions in fuel consumption. The U.S. Energy Information Administration (EIA) reference case forecasts that by 2040, more than 99% of light- and heavy-duty vehicles sold will still have internal combustion engines, therefore the potential fuel savings are tremendous.

VTO undertakes research and development activities to improve the efficiency of engines for both light and heavy-duty highway vehicles, whether they run on petroleum-based (gasoline and diesel) or alternative fuels. VTO supports every phase of research in these areas, from fundamental science to prototype demonstration. VTO’s research focuses on improving engine efficiency while meeting future federal and state emissions regulations. It does this through three main approaches:

- Developing advanced combustion strategies that maximize energy efficiency while minimizing the formation of emissions within the engine.
- Developing cost-effective aftertreatment technologies that further reduce exhaust emissions at a minimum energy penalty.
- Reducing losses and recovering waste energy.

Commercialization of these advanced combustion engine technologies could allow the United States to cut its transportation fuel use and corresponding greenhouse gas emissions by as much as 20 to 40%.

The Advanced Combustion Engine R&D subprogram supports a number of unique user facilities at the national laboratories. In addition to the national laboratories, research and development is done in collaboration with industry, other federal agencies (such as the National Science Foundation) and universities, as well as through government/industry partnerships:

- The U.S. Driving Research and Innovation for Vehicle efficiency and Energy sustainability (U.S. DRIVE) Partnership focusing on light-duty vehicles; and
- The 21st Century Truck Partnership, focusing on heavy-duty vehicles.

The major goals of the Advanced Combustion Engines R&D subprogram are:

- By 2015, increase the efficiency of internal combustion engines for passenger vehicles resulting in fuel economy improvements of 25% for gasoline vehicles and 40% for diesel vehicles, compared to 2010 gasoline vehicles. By 2020, improve the fuel economy of gasoline vehicles by 35% and diesel vehicles by 50%, compared to 2010 gasoline vehicles.

- By 2015, increase the efficiency of internal combustion engines for commercial vehicles from 42% (2010 baseline) to 50 % (representing a 20% improvement). This goal is part of the overall SuperTruck initiative to increase Class 8 truck freight hauling efficiency by more than 50% by 2015. By 2020, further improve engine efficiency to 55% (representing a 30% improvement) with demonstrations on commercial vehicle platforms.

These research and development activities are described annually at the Merit Review, and Progress Reports.

Subprogram Feedback

DOE received feedback on the overall technical subprogram areas presented during the 2015 Annual Merit Review (AMR).

The reviewers for a given subprogram area responded to a series of specific questions regarding the breadth, depth, and appropriateness of that DOE VTO subprogram's activities. The subprogram overview questions are listed below, and it should be noted that no scoring metrics were applied. These questions were used for all VTO subprogram overviews.

Question 1. Was the program area, including overall strategy, adequately covered?

Question 2. Is there an appropriate balance between near- mid- and long-term research and development?

Question 3. Were important issues and challenges identified?

Question 4. Are plans identified for addressing issues and challenges?

Question 5. Was progress clearly benchmarked against the previous year?

Question 6. Are the projects in this technology area addressing the broad problems and barriers that the Vehicle Technologies Office (VTO) is trying to solve?

Question 7. Does the program area appear to be focused, well-managed, and effective in addressing VTO's needs?

Question 8. What are the key strengths and weaknesses of the projects in this program area? Do any of the projects stand out on either end of the spectrum?

Question 9. Do these projects represent novel and/or innovative ways to approach these barriers as appropriate?

Question 10. Has the program area engaged appropriate partners?

Question 11. Is the program area collaborating with them effectively?

Question 12. Are there any gaps in the portfolio for this technology area?

Question 13. Are there topics that are not being adequately addressed?

Question 14. Are there other areas that this program area should consider funding to meet overall programmatic goals?

Question 15. Can you recommend new ways to approach the barriers addressed by this program area?

Question 16. Are there any other suggestions to improve the effectiveness of this program area?

Responses to the subprogram overview questions are summarized in the following pages. Individual reviewer comments for each question are identified under the heading Reviewer 1, Reviewer 2, etc. Note that reviewer comments may be ordered differently; for example, for each specific subprogram overview presentation, the reviewer identified as Reviewer 1 in the first question may not be Reviewer 1 in the second question, etc.

Subprogram Overview Comments: Gurpreet Singh (U.S. Department of Energy) – ace000

Question 1: Was the program area, including overall strategy, adequately covered?

Reviewer 1:
The reviewer said that yes, the program was adequately covered, and elaborated that the overall program goals and strategy were clearly presented and tied back to end-use results.

Reviewer 2:
The reviewer remarked that the overall objective of removing barriers to mass commercialization of high efficiency vehicles was clearly communicated.

Reviewer 3:
The reviewer said that the presentation was very well thought out, outlining a strategy focusing on improving efficiency (and thus petroleum dependency) while reducing emissions. The reviewer noted that the role of government laboratories in fundamentals through applied research leading ultimately to technology transfer to industry was described well, followed up with a strong overview of the portfolio of projects being pursued by the laboratories and, in many cases, their industrial collaborators and partners.

Question 2: Is there an appropriate balance between near- mid- and long-term research and development?

Reviewer 1:
The reviewer noted that the bulk of the research & development (R&D) activity is mid-term to long-term. The reviewer identified that there are significantly fewer projects that are truly near-term, though that may be the most appropriate balance for this program area in any case, as near-term work is almost exclusively competitive in nature and therefore inappropriate for federal involvement.

Reviewer 2:
The reviewer said that there seems to be a balance of programs focused on near-, mid-, and long-term R&D.

Reviewer 3:
The reviewer noted that there is a clear pipeline of research bridging long-, mid-, and near-term work ranging from fundamental, laboratory research to near-production hardware proof-of-concept work. These various projects appear to be intelligently assigned to organizations best suited for their successful completion.

Question 3: Were important issues and challenges identified?

Reviewer 1:
The reviewer commented that the stage is set at the beginning of the presentation to give a good overview of the issues and challenges facing combustion engine development; targets and goals are clearly delineated.

Reviewer 2:
The reviewer noted that the issues of improving fuel consumption, reducing petroleum dependence, and continuing to reduce vehicle emissions were mentioned.

Reviewer 3:
The reviewer said that the important issues were well identified. The challenges were also largely covered in a useful way. The reviewer remarked that the main area where there may be disconnect is in coupling the technology R&D to consumer choice in purchasing the technology and the impact of fuel price. It is outside the scope of the Advanced Combustion Engine (ACE) program to fix those challenges, but they end up being a key factor in the speed of market penetration for the technology.

Question 4: Are plans identified for addressing issues and challenges?

Reviewer 1:

The reviewer said that a variety of approaches and programs were mentioned as the means for addressing the issues and challenges.

Reviewer 2:

The reviewer pointed out that although a high-level presentation, the overall program plan addresses the issues and challenges raised in reasonable detail given the time constraints of the venue. According to the reviewer, of course, this presentation naturally led into the more detailed individual project presentations to be covered during the subsequent sessions, but it was a good overview that laid out the general framework and a surprising amount of technical detail in so short a time.

Reviewer 3:

The reviewer remarked that these are reasonable plans. The reviewer expected that there will be many more challenges in implementing many of the technologies at the vehicle integration stage (transient performance, drive-cycle emissions, extreme environment compatibility, real-world fuel variability impact, etc.). The reviewer suggested that additional program focus on these topics at Oak Ridge National Laboratory (ORNL) and Argonne National Laboratory (ANL) would be valuable as these challenges can kill otherwise promising technologies and vehicle/engine manufacturers may or may not be willing to work on overcoming those challenges in their product development decisions.

Question 5: Was progress clearly benchmarked against the previous year?

Reviewer 1:

The reviewer found that progress was well benchmarked in that the projects highlighted in the presentation demonstrated good advances from where the project team was in the previous year.

Reviewer 2:

The reviewer pointed out that recent progress was mentioned.

Reviewer 3:

The reviewer observed that progress is described more in multi-year terms rather than specifically geared towards the last year. In some ways, the reviewer found this is preferable as the problems being tackled are complex and take many years to reach final solution. However, the point is taken and perhaps some year-to-year benchmarks could be added.

Question 6: Are the projects in this technology area addressing the broad problems and barriers that the Vehicle Technologies Office (VTO) is trying to solve?

Reviewer 1:

The reviewer said that the projects in the ACE program are key parts of the broad problems/barriers that the VTO needs to address. The core importance of the internal combustion engine was well communicated in the presentation.

Reviewer 2:

The reviewer commented that the projects are focused on key issues of importance to VTO: improving fuel consumption, reducing petroleum dependence, and continuing to reduce vehicle emissions were all mentioned.

Reviewer 3:

The reviewer said that the projects here are very clearly working towards higher efficiency, energy independence, lower emissions, etc., which are all key problems and barriers that VTO is working to address.

Question 7: Does the program area appear to be focused, well-managed, and effective in addressing VTO's needs?

Reviewer 1:

The reviewer concluded that yes, the program area appears to be focused, well-managed and effective.

Reviewer 2:

The reviewer found that the program is well focused, covering most key areas needed to address the VTO's needs. It appears to be well-managed and effective, making significant progress on many fronts.

Reviewer 3:

The reviewer found that the program is highly focused and is well managed. The reviewer advised some broadening of the program, at least in a few key areas. The reviewer detailed that the program is heavily invested in low-temperature combustion and low-temperature catalysis. These two technologies are tied together, as engines using low-temperature combustion require the low-temperature catalysts. However, according to the reviewer, there are ongoing difficulties in fully integrating these engines into vehicles, such as acceptable transient performance, ability to boost and run sufficient exhaust gas recirculation (EGR), and catalyst thermal management for extended idle or hybrid applications. To provide some insurance against these integration-level challenges, the reviewer suggested that additional program activity looking at approaches that are less out-there but that also offer nearer-term potential would be of value. Some of these approaches might be high-dilution stoichiometric combustion where the aftertreatment is simpler, or advanced stratified compression ignition combustion that is not to the level of the premixed charge compression ignition/homogenous charge compression ignition/reactivity controlled compression ignition (RCCI).

Question 8: What are the key strengths and weaknesses of the projects in this program area? Do any of the projects stand out on either end of the spectrum?

Reviewer 1:

The reviewer identified that a key strength is a project portfolio in the advanced combustion area having a spectrum of different combustion approaches (i.e., dual fuel RCCI, partial premixing, lean and dilute EGR spark ignition, etc.) with a range from fundamental research to testing in multi-cylinder engines and vehicles.

Reviewer 2:

The reviewer remarked that the key strength is integrating the research between the laboratories, universities, and industrial partners. In most cases, the technologies being imagined and pursued at the fundamental level are filtering into the hands of the vehicle and engine manufacturers. The reviewer remarked that if anything, the collaborations between the laboratories, universities, and industry should be strengthened to speed-up this process. The reviewer said that where no clear commercialization path appears to be in place, for example the KIVA-hpFE development, more aggressive work towards getting the technology adopted by commercial software companies should be pursued.

Reviewer 3:

The reviewer identified that the work on stochastic processes is key; as the industry pushes the engines farther, the cycle-to-cycle variability becomes a huge limiting factor on getting efficiency. DOE's capability in this area is at the forefront of the subject. The reviewer noted that the Engine Collaboration Network (ECN) work is also a unique contribution that the DOE brings to the research community. The long-term work at Sandia National Laboratories in this area has been a massive investment in understanding compression ignition combustion. The reviewer remarked that the KIVA development is much weaker; DOE's own programs are splitting the effort between providing tools that plug into commercial codes like Converge, and still invest in the development of KIVA. But the reviewer sees significantly less interest in KIVA from the end users at engine/vehicle companies. It is not clear how this project provides value in proportion to its funding. The reviewer noted that the large awards to the engine/vehicle manufacturers are always somewhat challenging to rate. These projects demonstrate results, but provide minimal technical learning back to the combustion community, and there is not always an obvious linkage between the R&D and eventual product improvement. The reviewer does not know how to make this better, but it is something that stands out as a challenge.

Question 9: Do these projects represent novel and/or innovative ways to approach these barriers as appropriate?

Reviewer 1:

The reviewer remarked that there is a good level of novelty and innovation in many of the projects. The projects variously leverage unique capability at the DOE laboratories, link together groups of researchers in ways that provide outsized benefits, and investigate topics that industry would not otherwise look to.

Reviewer 2:

The reviewer responded that yes, the ways to approach barriers are appropriate and elaborated that for the most part the national laboratory and university recipients of DOE awards are very knowledgeable and highly creative.

Reviewer 3:

The reviewer said that the projects show a lot of innovation being applied to overcoming the barriers.

Question 10: Has the program area engaged appropriate partners?

Reviewer 1:

The reviewer said that the program area has an excellent set of partners that cover key universities, the laboratory researchers, end-use industries (vehicle/engine manufacturers), and component suppliers.

Reviewer 2:

The reviewer identified that opportunities for engagement with industry range from annual AMR reviews, to semi-annual Advanced Engine Combustion Memorandum of Understanding (AEC MOU) meetings, to participation for some in specific programs. Some projects have significantly more engagement with industry than others.

Reviewer 3:

The reviewer commented that through the AEC MOU, many engine producers and energy companies have been engaged, while the DOE-National Science Foundation grants have brought in many leading universities into the mix. The reviewer noted that the Cross-Cut Lean Exhaust Emission Reduction Simulation (CLEERS) performs a similar role in the emissions control area. Greater participation by code vendors and component suppliers (injectors, turbos, etc.) might be helpful though.

Question 11: Is the program area collaborating with them effectively?

Reviewer 1:

The reviewer said that the collaborations appear to be effective with open communication in both directions.

Reviewer 2:

The reviewer said that there is clear and close collaboration between the various partners.

Reviewer 3:

The reviewer noted that for the overall program area, opportunities for engagement with the energy industry consists of the AMR and semi-annual AEC MOU meetings.

Question 12: Are there any gaps in the portfolio for this technology area?

Reviewer 1:

The reviewer saw no gaps.

Reviewer 2:

The reviewer referenced prior comments, and elaborated that additional projects looking at non-low-temperature combustion (LTC) areas would be the biggest gap this reviewer perceives, along with addressing challenges to implementing LTC on vehicles that can do everything that the vehicle has to do.

Reviewer 3:

The reviewer referenced prior comments that adding more participation by component and analysis tool providers might be beneficial.

Question 13: Are there topics that are not being adequately addressed?

Reviewer 1:

The reviewer said that the portfolio appears to be very broad and addresses the problems adequately.

Reviewer 2:

The reviewer said none.

Reviewer 3:

The reviewer had no comments that would be different than prior comments.

Question 14: Are there other areas that this program area should consider funding to meet overall programmatic goals?

Reviewer 1:

The reviewer said that funding appears adequate.

Reviewer 2:

The reviewer suggested seeing prior comments.

Reviewer 3:

The reviewer expressed no suggestions.

Question 15: Can you recommend new ways to approach the barriers addressed by this program area?

Reviewer 1:

The reviewer expressed a preference to see more of ORNL's and ANL's effort focused on going all the way to vehicles or at least simulated vehicle engine testing so that the full scope of making the combustion and catalyst developments coming out of the program are production-realizable.

Reviewer 2:

The reviewer suggested perhaps more focus groups like the ECN for other key issues, such as soot modeling for instance, may be helpful.

Reviewer 3:

The reviewer had no recommendations.

Question 16: Are there any other suggestions to improve the effectiveness of this program area?

Reviewer 1:

The reviewer said that additional discussion and information on technology needs would be valuable. The long-term plans are clearly heavily influenced by input from the automotive and truck manufacturers, but there sometimes appears to be disconnect between what these OEMs tell DOE to focus R&D on and what the manufacturers focus on for their visible R&D. This reviewer would like to see more obvious and visible coordination and connection between DOE's projects and what ends up going towards production to ensure the best use of federal funds. The reviewer explained that there is huge potential in the internal combustion engine, so ensuring that what the ACE program works on gets to production will be a huge benefit to us all.

Reviewer 2:

The reviewer suggested perhaps sponsoring deep dive webinars for the various laboratory projects between AEC MOU meetings might provide some additional opportunities to interact with the researchers, and would result in getting more details out than possible in the twice annual meetings, etc.

Reviewer 3:

The reviewer stated no suggestions.

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.

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Heavy-Duty Low-Temperature and Diesel Combustion and Heavy-Duty Combustion Modeling	Musculus, Mark (SNL)	4-17	3.70	3.60	3.60	3.80	3.65
Light-Duty Diesel Combustion	Busch, Stephen (SNL)	4-22	3.20	3.00	3.30	3.30	3.13
Low-Temperature Gasoline Combustion (LTGC) Engine Research	Dec, John (SNL)	4-26	3.00	3.38	3.00	3.50	3.25
Spray Combustion Cross-Cut Engine Research	Pickett, Lyle (SNL)	4-28	3.67	3.67	3.75	3.42	3.65
Automotive Low-Temperature Gasoline Combustion Engine Research	Ekoto, Isaac (SNL)	4-33	2.70	3.00	3.60	2.90	2.99
Large Eddy Simulation (LES) Applied to Advanced Engine Combustion Research	Oefelein, Joe (SNL)	4-36	3.20	3.40	3.10	3.10	3.28
Fuel Injection and Spray Research Using X-Ray Diagnostics	Powell, Christopher (ANL)	4-41	3.38	3.38	3.13	3.00	3.30

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Use of Low-Cetane Fuel to Enable Low-Temperature Combustion	Ciatti, Steve (ANL)	4-45	3.29	3.00	3.14	3.29	3.13
Model Development and Analysis of Clean and Efficient Engine Combustion	Whitesides, Russell (LLNL)	4-50	3.50	3.33	3.42	3.00	3.34
Chemical Kinetic Models for Advanced Engine Combustion	Pitz, Bill (LLNL)	4-54	3.70	3.70	3.50	3.40	3.64
2015 KIVA-hpFE Development: A Robust and Accurate Engine Modeling Software	Carrington, David (LANL)	4-57	3.00	3.00	2.50	2.67	2.90
Stretch Efficiency for Combustion Engines: Exploiting New Combustion Regimes	Daw, Stuart (ORNL)	4-62	3.00	3.10	2.80	3.10	3.04
High-Efficiency Clean Combustion in Multi-Cylinder Light-Duty Engines	Curran, Scott (ORNL)	4-67	3.50	3.25	3.33	3.25	3.32
Accelerating Predictive Simulation of Internal Combustion Engines with High Performance Computing	Edwards, Kevin (ORNL)	4-71	3.07	3.14	3.43	3.14	3.16

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Joint Development and Coordination of Emissions Control Data and Models (CLEERS Analysis and Coordination)	Daw, Stuart (ORNL)	4-77	3.88	3.75	3.75	3.38	3.73
CLEERS: Aftertreatment Modeling and Analysis	Peden, Chuck (PNNL)	4-81	3.25	3.50	4.00	3.25	3.47
Particulate Emissions Control by Advanced Filtration Systems for GDI Engines	Seong, Hee Je (ANL)	4-84	3.50	3.25	2.75	3.25	3.25
Enhanced High- and Low-Temperature Performance of NO_x Reduction Materials	Gao, Feng (PNNL)	4-86	3.67	3.33	3.33	3.33	3.42
Thermally Stable Ultra Low-Temperature Oxidation Catalysts	Karkamkar, Abhijeet (PNNL)	4-89	3.30	3.10	3.10	3.20	3.16
Cummins/ORNL-FEERC CRADA: NO_x Control and Measurement Technology for Heavy-Duty Diesel Engines	Partridge, Bill (ORNL)	4-93	3.40	3.40	3.60	3.30	3.41
Emissions Control for Lean Gasoline Engines	Parks, Jim (ORNL)	4-97	3.50	3.50	3.50	3.50	3.50

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Neutron Imaging of Advanced Transportation Technologies	Toops, Todd (ORNL)	4-101	3.30	3.30	3.40	3.00	3.28
RCM Studies to Enable Gasoline-Relevant Low-Temperature Combustion	Goldsborough, Scott (ANL)	4-105	3.50	3.13	3.38	3.13	3.25
Fuel-Neutral Studies of Particulate Matter Transport Emissions	Stewart, Mark (PNNL)	4-109	3.50	3.25	3.50	3.00	3.31
Cummins SuperTruck Program Technology and System Level Demonstration of Highly Efficient and Clean, Diesel Powered Class 8 Trucks	Koeberlein, David (Cummins)	4-112	3.71	3.79	3.79	3.67	3.75
SuperTruck Program: Engine Project Review	Singh, Sandeep (Detroit Diesel)	4-117	3.57	3.71	3.64	3.33	3.62
Development and Demonstration of a Fuel-Efficient Class 8 Tractor and Trailer	Zukouski, Russ (Navistar International Corp.)	4-122	3.08	2.92	3.42	2.92	3.02
Volvo SuperTruck - Powertrain Technologies for Efficiency Improvement	Gibble, John (Volvo)	4-126	3.56	3.44	3.50	3.31	3.46

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
ATP-LD; Cummins Next-Generation Tier 2 Bin 2 Diesel Engine	Ruth, Michael (Cummins)	4-131	3.33	3.67	3.33	3.25	3.49
Advanced Gasoline Turbocharged Direct Injection (GTDI) Engine Development	Weaver, Corey (Ford Motor Company)	4-135	3.70	3.60	3.20	3.60	3.58
Advancements in Fuel Spray and Combustion Modeling with High Performance Computing Resources	Som, Sibendu (ANL)	4-139	3.30	3.40	3.60	3.20	3.38
Improved Solvers for Advanced Engine Combustion Simulation	McNenly, Matthew (LLNL)	4-143	3.50	3.70	3.50	3.80	3.64
Cummins/ORNL-FEERC Combustion CRADA: Characterization and Reduction of Combustion Variations	Partridge, Bill (ORNL)	4-147	3.50	2.90	3.30	3.00	3.11
Investigation of Mixed Oxide Catalysts for NO Oxidation	Szanyi, Janos (PNNL)	4-151	3.38	3.25	3.13	3.00	3.23
Robust Nitrogen Oxide/Ammonia Sensors for Vehicle On-board Emissions Control	Mukundan, Rangachary (LANL)	4-154	3.20	3.40	3.10	3.10	3.28

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
High Efficiency GDI Engine Research, with Emphasis on Ignition Systems	Wallner, Thomas (ANL)	4-157	2.92	3.25	2.92	3.08	3.10
Low-Temperature Emission Control to Enable Fuel Efficient Engine Commercialization	Toops, Todd (ORNL)	4-161	3.67	3.33	3.33	3.33	3.42
Next-Generation Ultra-Lean Burn Powertrain	Bunce, Mike (MAHLE Powertrain LLC)	4-164	3.14	3.07	2.79	3.17	3.07
Development of Radio Frequency Diesel Particulate Filter Sensor and Controls for Advanced Low-Pressure Drop Systems to Reduce Engine Fuel Consumption	Sappok, Alexander (Filter Sensing Technologies, Inc.)	4-169	3.50	3.70	3.50	3.30	3.58
High-Dilution Stoichiometric Gasoline Direct-Injection (SGDI) Combustion Control Development	Kaul, Brian (ORNL)	4-173	3.07	2.86	2.57	2.86	2.88
Intake Air Oxygen Sensor	Schnabel, Claus (Robert Bosch)	4-177	3.00	2.60	2.70	2.80	2.74
High-Efficiency VCR Engine with Variable Valve Actuation and New Supercharging Technology	Mendler, Charles (Envera LLC)	4-181	2.81	2.88	2.50	2.75	2.80

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Lean Miller Cycle System Development for Light-Duty Vehicles	Sczomak, David (General Motors)	4-186	3.42	3.08	2.50	3.50	3.15
Ultra-Efficient Light-Duty Powertrain with Gasoline Low-Temperature Combustion	Confer, Keith (Delphi Powertrain)	4-191	3.13	3.25	3.25	3.13	3.20
Metal Oxide Nano-Array Catalysts for Low-Temperature Diesel Oxidation	Gao, Pu-Xian (U. Conn)	4-195	3.50	3.30	3.20	3.30	3.34
Overall Average			**3.35**	**3.30**	**3.26**	**3.21**	**3.30**

Heavy-Duty Low-Temperature and Diesel Combustion and Heavy-Duty Combustion Modeling: Mark Musculus (Sandia National Laboratories) - ace001

Presenter

Mark Musculus, Sandia National Laboratories.

Reviewer Sample Size

A total of five reviewers evaluated this project.

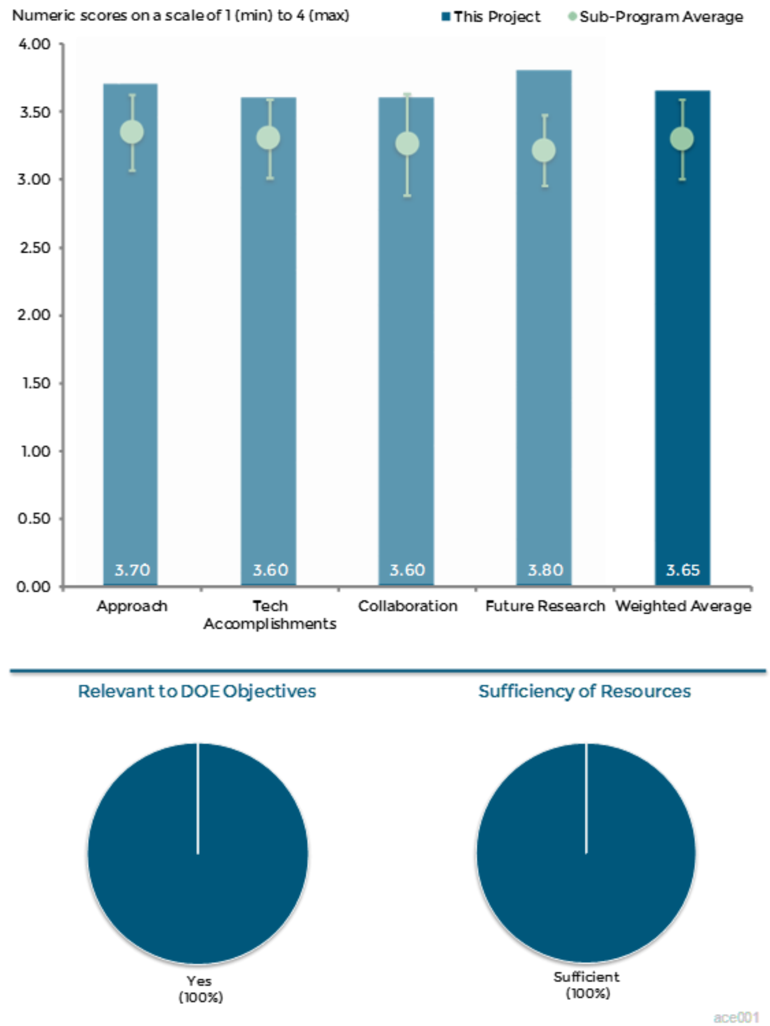

Figure 4-1 Heavy-Duty Low-Temperature and Diesel Combustion and Heavy-Duty Combustion Modeling: Mark Musculus (Sandia National Laboratories) – Advanced Combustion Engines

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer observed the approach of combining planar laser-imaging diagnostics in optical engine with multi-dimensional computer modelling to better understand low-temperature combustion seems very effective.

Reviewer 2:

The reviewer acknowledged the project has a very thoughtful and stepwise approach to build the fundamental understanding of DI combustion, but warned that the biggest challenge is that so much is being done that it is hard to evaluate each piece fully with the limitations of the presentation time. The reviewer reported the top level goal is of great importance. The past findings at Sandia on diesel combustion have become an integral part of engine combustion knowledge and the extensions currently being worked on are equally important for future engine development. The reviewer remarked the development of the thermal imaging for vapor penetration is very interesting and would like to see more development and validation of the technique to understand it better. In addition, the heat transfer study is very important, though there will continue to be limitations since the work is on a skip-fired optical engine. The reviewer expressed an interest to see a specific collaboration with some other entity that could support metal engine experiments that extend/validate the work done. There is good justification made for some of the work to be done at Sandia National Laboratories (SNL) since correlation with the optical work is valuable. It was noted the soot formation and oxidation work is very exciting, and is a perfect example of the value of optical engine work since these results would be unobtainable anywhere else.

Reviewer 3:

The reviewer noted that the approach of using optical engine diagnostics with infrared imaging for study of vapor fuel mixing and combustion wall heat flux is very interesting and pointed out the infrared (IR) camera provides a simple setup to visualize vapor jet boundaries.

Reviewer 4:

The reviewer said that the combination of in-cylinder optical diagnostics and computational fluid dynamics (CFD) simulations are a powerful method to gain understanding of the various issues facing diesel engine designers, but warned that the broad scope of the research being pursued means that attention is being split many different ways. In addition, the comment was made that by focusing on fewer topics might provide greater leadership and progress in these areas.

Reviewer 5:

The reviewer suggested a recommendation for more emphasis on tool development to improve the science base of dilute spark ignition (SI) gasoline combustion.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer remarked that developing CFD analysis tools for insight into post injection mechanisms. The reviewer applauded the efforts with IR thermometry. The reviewer encouraged focusing on robust coating solution and eliminating pin holes.

Reviewer 2:

The reviewer remarked that there was clearly quite a bit of technical accomplishment. The biggest concern seen is that with four areas worked on, there would be concern that each got less time than it deserved for the value of each area individually. The reviewer observed that the partial premixing work is a project unto itself, and acknowledged that findings from this project with respect to mixing and incomplete combustion have been highly valuable over the years, and the complexity that comes with multiple injections makes this appear to be a massive undertaking. It was also pointed out that the results presented this year are a teaser for what will be done more than as results to work with independently. The reviewer commented that the vapor penetration diagnostic is a very interesting new tool, but expressed an interest to see much more on this task alone to find out what one has really learned from it and what else one could learn from it. It was mentioned the heat transfer work is another area where the tools are in development, but the results are not yet in. The reviewer also expressed an excitement to see what one learn in this area but there is not much to take away as a learning yet, and noticed the soot oxidation and formation work is very exciting and remarked to have some already useful learning from that work, even though it is going to be a continuing area of work.

Reviewer 3:

The reviewer observed that the discovery that in partial premixing, the increase in ignition delay with injection duration cannot be explained by mixture fraction, which is counter to what is expected. The reviewer mentioned that thermal IR imaging can provide vapor-fuel penetration data with simpler optical access requirements than Schlieren, and stated that there is some progress in evaluating two new heat transfer diagnostic methods which may ultimately help to improve accuracy of heat transfer models. Initial development of a soot formation and oxidation model that suggests as the post-injection fuel penetrates, it promotes faster combustion and consumes fuel from the main fuel injection and thus reduces soot from the main injection.

Reviewer 4:

The reviewer remarked that the progress is good in each area being investigated, but questioned if more significant progress could be made with more focused study of fewer topics.

Reviewer 5:

The reviewer observed that some very interesting conclusions were made with regard to the post injection interaction with the combustion residuals of main injection. It was pointed out that in future efforts from an industry perspective it would be great to expand on the idea of tailoring the mixing and scalar gradient distribution. The reviewer inquired about how that can be physically controlled with some injector or combustion bowl design changes. The reviewer commented that the observation of wall heat flux not being in phase with cylinder pressure can use some additional fundamental explanation.

Question 3: Collaboration and Coordination with other institutions.

Reviewer 1:

The reviewer commented the collaboration with both direct partners and the Advanced Combustion and Emission Control (ACEC) team provides excellent coordination with relevant partners to address parts of the work which cannot be accommodated at SNL. In addition, the reviewer would encourage seeking some partnership that can support the heat flux measurements with metal engines and other measurement methods.

Reviewer 2:

The reviewer pointed out that the national laboratory interaction and collaboration in all of the Advanced Combustion Engine (ACE) projects are self-evident at Annual Merit Review (AMR). The community is excellently connected and efficiently shares research, and collaborates. The advanced engine combustion working group effectively disseminates information to the industry through workshops. The reviewer commented that it would be great to get a survey from the industry partners as to how this research gets translated into the workings of their own corporate research and development (R&D) departments.

Reviewer 3:

The reviewer offered that coordination with other U.S. Department of Energy (DOE) projects, particularly those at SNL, is very good. It was noted that more collaboration with other laboratories such as Argonne National Laboratory (ANL) with respect to their Advanced Photon Source (APS) injector studies would be welcomed. Similarly with universities, the reviewer said collaboration with the UW (UW), particularly in the area of CFD modeling, of effects of main/post injections and soot formation combined with in cylinder diagnostics at SNL is stunning, but can more be done by adding partners in other areas such as heat transfer which seems to be a topic of interest. The reviewer also remarked, for example, that there might be some work with Pennsylvania State University’s radiation modeling National Science Foundation (NSF) project.

Reviewer 4:

The reviewer remarked that all work is conducted within Advanced Engine Combustion (AEC) which is a broad collaboration. It was said that other university contacts outside of AEC might better show leveraging of research findings.

Reviewer 5:

The reviewer pointed out that there is some collaboration with two original equipment manufacturers (OEMs) (Cummins & Delphi), one simulation software development company (Convergent Science, Inc. [CSI]), and one university, (UW). Collaboration with the AEC Memorandum of Understanding (MOU) members was generally mentioned, but no specifics were given. The reviewer stated that while collaboration may occur as part of these types of conference venues, very limited information was provided on planned collaborative efforts.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer commented that the future plans are exciting and follow the overall project strategy well. There is clearly a lot planned so making sure that there is adequate focus on each topic will be a challenge, as well as communicating the findings well.

Reviewer 2:

The reviewer remarked that the plans to continue building the conceptual model of multiple injection processes and determining how combustion design affects heat transfer and efficiency, should continue the very good progress that has been made.

Reviewer 3:

The reviewer observed heat transfer is a particularly interesting topic to diesel manufacturers trying to increase efficiency and maybe looking at thermal barrier coating and material effects might be worthwhile. However, the reviewer expressed a need to not add even more topics to an already crowded program. Soot diagnostics work and the relationships with injection should definitely be continued, but getting results in hands of modelers and ultimately commercial code vendors to aid in improving software tools should be a priority.

Reviewer 4:

The reviewer noted that the future work expands into more than two injection invents, and expressed that it would great to see some results in that scope next year. The reviewer remarked that some ideas are also required towards combustion control strategies.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer pointed out that improved understanding on spray, mixing, combustion may allow revised designs and strategies for improved fuel economy (FE) and lower emissions.

Reviewer 2:

The reviewer observed that a better understanding of the combustion process will lead to better engine designs with higher efficiencies and hence lower petroleum consumption.

Reviewer 3:

The reviewer expressed an agreement that the project and research is relevant to fundamental understanding of in-cylinder combustion processes towards enhancing efficiency.

Reviewer 4:

The reviewer pointed out that improving knowledge of in-cylinder spray, combustion, and pollutant formation processes for both conventional diesel and low-temperature combustion is important for the development and commercialization of more efficient engines that lead to lower petroleum usage.

Reviewer 5:

The reviewer highlighted that in terms of enabling high-efficiency direct injection (DI) combustion, the fundamental understanding that is being pursued is key for unlocking new concepts for production engines. The reviewer expressed a preference for a shift in balance towards more conventional combustion because aftertreatment effectiveness has improved enough to enable low NO_x and PM with a hot combustion system. Investigating if extensions to Dec's earlier work are warranted would be a useful parallel effort. This reviewer expressed a realization that runs counter to the comments on focus and multiple tasks from above and is not sure of how those could be reconciled.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer pointed out that approximately $834,000 per year is provided between SNL and UW, but mentioned that it is not clear what additional funding would directly allow.

Reviewer 2:
The reviewer indicated the resources appear to be adequate for allowing ongoing progress with good results on an annual basis. Having watched the program for many years, there is a significant track record of good progress at the funding levels which have been made available.

Reviewer 3:
The reviewer noted that good progress with existing funds suggests that funding is sufficient.

Reviewer 4:
The reviewer commented that the resources seem adequate.

Light-Duty Diesel Combustion: Stephen Busch (Sandia National Laboratories) - ace002

Presenter

Stephen Busch, Sandia National Laboratories.

Reviewer Sample Size

A total of five reviewers evaluated this project.

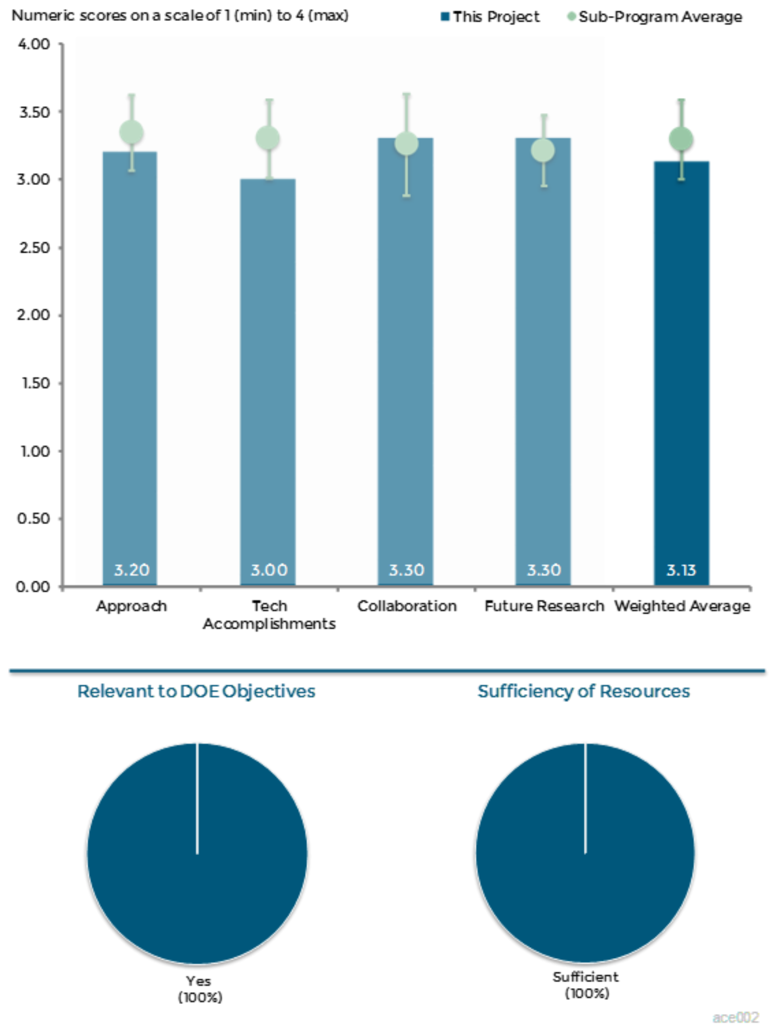

Figure 4-2 Light-Duty Diesel Combustion: Stephen Busch (Sandia National Laboratories) – Advanced Combustion Engines

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that there is excellent close coupling between the experimental, diagnostics and simulation.

Reviewer 2:

The reviewer reported that the approach is good. It is made up of primarily optical engine work which is supported with simulations by UW and also has CFD support from CSI.

Reviewer 3:

The reviewer pointed out that this project appears to have received sustained activity for almost 20 years (since 1997). It is organized around developing a fundamental understanding of engine combustion processes through a combination of simulation and experiments, and the focus is on conventional combustion dynamics with emphasis this year on combustion noise. The test bed is a single cylinder engine at SNL where in-cylinder flow characterization is pursued and with UW using the data to develop improved predictions using the Converge code. The project notes that the General Motors (GM) 1.9 liter (L) engine is a common platform, though it seems that only the SNL optical engine (objective 1) and computational work (objective '). The reviewer questioned if a 1.9L engine was used, but acknowledged that the UW appears to be using the Converge code in their simulation to apparently improve its capabilities using the SNL single cylinder engine data. The reviewer noted that there are other parts of the Vehicle Technologies Office (VTO) program that are also using this same code, for example at ANL. It was questioned what UW is doing with Converge that ANL is not, or vice-versa. The reviewer noted that the use of KIVA has been extensively developed by UW in collaboration with SNL. UW and SNL are apparently now using Converge in this project. A comment was made that some discussion for the reason for the switch would be beneficial beyond simply that their industrial collaborators are using it. Presumably, the project team would be advocating for KIVA if it is felt it to be a valuable code.

Reviewer 4:

The reviewer warned that the presentation does not do a very good job of justifying the project relevance. Both this project and Musculus' project are looking at the impact of multiple injections. To be sure, there are differences between how the injection behaves in a large-bore and a small-bore engine, but there is little discussion of how the projects will be complementary in that regard. The reviewer commented that the project goals of evaluating combustion noise and engine efficiency are at odds with the experimental hardware. Those topics would be much more effectively studied on multi-cylinder engines (MCE) with real hardware. It was pointed out there is not much value to optical tools for either of those areas. If the reviewer missed something, it should have been brought out in the slides. The reviewer noted that there is also little discussion of how light-duty compression ignition (CI) engines are developing in the production/pre-production world. The challenges of simply meeting Tier 3/Low Emission Vehicle (LEV) III emissions is a huge challenge for light-duty CI engines going forward. The reviewer commented that support from SNL on technical issues still would support the DOE objective of petroleum reduction. This reviewer noted that if emissions regulations push diesel engines out of the light-duty market then fuel consumption will increase. The reviewer mentioned that more background needs to come across in terms of how the present work improves or replaces work done previously on the program by Miles, and commented that just showing the particle image velocimetry (PIV) results superficially looks like a repeat of work that has been done, which makes it hard for the reviewers to fairly evaluate the current efforts.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer noted that understanding of noise reduction mechanism thru multiple injections will be very interesting and much needed, but was not sure how heat release from the pilot (1.5 milligrams (mg) can cancel that from main (20 mg). The reviewer commented that the efforts to validate models are encouraged and commended, and observed that an effort to correct PIV distortion is commendable. It is encouraging to see that swirl ratio from PIV correlates with swirl ratio form steady state bench. This reviewer remarked that the CSI simulations also predict the same swirl center location. Axis tilt with crank angle is qualitative early, but much better later on. The reviewer understands that the PI is having problems measuring squish flows and that these problems with PIV are associated with trying to get a thin laser sheet in the squish region, and mentioned that the beam steering and reflections occur. It was questioned if the project team can do Laser Doppler Anemometry (LDA) measurements. The reviewer mentioned that about 30 years ago, LDA was used to measure squish flows, and questioned if simulations have been exercised to see what the PI can expect for squish flow behavior.

Reviewer 2:

The reviewer said that leveraging destructive interference is an interesting approach, but questioned if there is concern this would not be robust in a production type environment. The reviewer asked if there is any consideration of an adaptive approach using sensor feedback, but commented that it was good to see combustion noise metric decibel (dBA) rather than ringing intensity.

Reviewer 3:

The reviewer stated that the main accomplishment seen in the presentation is that better PIV results are available which can be used to validate CFD, which is useful, and is a necessary step towards higher fidelity simulations. It was reported that it is not presented in a context where one can point to specific improvements in our understanding of light-duty CI combustion. This reviewer then pointed out that, in general, that is the biggest strength of the SNL is optical work, and the improvement in CFD models is a nice second outcome. The combustion noise result seems interesting, but it is very unclear if this finding is particularly useful. Beyond that, the study does not seem to make use of any specific capability that the optical engine offers. If it does not, then the study should probably be done elsewhere so that resources at SNL can be devoted to what only can be done there.

Reviewer 4:

The reviewer described the time for analytical image processing for distortion correction as well spent.

Reviewer 5:

The reviewer indicated that the connection between an improved understanding of flow in the SNL engine and measureable and quantifiable gains in engine efficiency were weak, and explained that detailed PIV measurements and turbulent flow in-cylinder simulations are interesting and can provide much needed data for validating engine codes. However, a greater connection of the results to engine efficiency would be beneficial. The reviewer highlighted that the science is good, but the connection to efficiency needs to be strengthened.

Question 3: Collaboration and Coordination with other institutions.

Reviewer 1:

The reviewer stated that there is good coordination with UW and CSI, which will enable advances in modeling tools. There needs to be much stronger coordination with the engine manufacturers and probably with Oak Ridge National Laboratory (ORNL), as planned, but there are a number of aspects to this program that seem better suited to metal engine experiments or to close linkage to parallel metal engine experiments.

Reviewer 2:

The reviewer commented that the project team has very good collaborations exist with UW and CSI.

Reviewer 3:

The reviewer indicated that the collaborative team makes sense, including team members who are experts with experiments and computational simulations. It was pointed out there are other organizations that are developing numerical tools using similar data (e.g., single cylinder engine data) that have ostensibly similar computational capabilities. The reviewer suggested that it would be useful to reach out (if only informally) to such groups to see where there may be overlap.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer reported that the squish flow work is valuable and indicated much of the emissions and heat transfer can be tied to flow and combustion in this area. The reviewer then stated that the split injection work needs to be differentiated from the work on the heavy-duty CI engine somehow. It was explained there are obvious differences in the combustion system but it is not clear from the material presented how the proposed work will fit with the other project. The reviewer also suggested that better differentiation between the work at UW and CSI is probably needed as well to make clear where the advanced research on CFD and the production enabling of CFD come into play.

Reviewer 2:

The reviewer remarked that the code selected for study (Converge) provides impressive simulations as noted in the presentation. However, this reviewer mentioned that the PIs have also developed impressive simulations with other codes in their past work (KIVA). It was reviewer this issue deserves some further attention in their work going forward. The reviewer said the plan to study piston bowl geometries is interesting, though some work along this line has been reported in the past, but commented that it was not clear what is new here, or what rationale is being applied to inform the selection of the bowl geometry. This reviewer then concluded that it seemed sort of like a trial process to fabricate a bowl geometry, see how it performs and then revise it. The reviewer pointed out that the future work seems to be framed around the SNL single cylinder engine, but noted it is unclear how the GM 1.9L engine fits into the work going forward. The reviewer indicated that the computational work seems to focus on single cylinder performance predictions with the Converge growth, but warned it was not clear from what was presented if the computational tools have the capability to couple fluid/thermal transport processes and materials stress issues that result from repeated temperature cycling as the engine operates. If not, and the presentation did not appear to mention this issue, this should be included in future work. It was explained that materials issues can be determinative to long term performance at high engine efficiency. Issues like yield stress, crack growth and failure, etc., are important considerations in long-term sustained operation, especially because these properties are strongly coupled to temperature which is an output of the computational effort of the in-cylinder predictions. The reviewer concluded that the computational work should endeavor to integrate such coupling to make the computational tools more relevant to long-term engine performance.

Reviewer 3:

The reviewer indicated that squish flow behavior should be understood early by exercising the model, and this will help understand to interpret engine data when injection timings are swept.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer commented that this work is broadly relevant to engine performance as it concerns predicting in-cylinder processes and noise generated by the combustion process, but added that to make the work even more relevant, the PIs should try to quantitatively couple what the team is doing to specific efficiency metrics, and to fold materials stress considerations into their predictions.

Reviewer 2:

The reviewer expressed that there are needs to improve fuel economy from light duty (LD) diesel engines and at a high level the project is tied into that goal, and added that there needs to be better definition of how the tasks in this project will provide unique and necessary information towards that goal though.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer noted that the funding seems heavily weighted between SNL and UW at five times to one, while the project is presented as almost an equal share, with SNL taking data and UW using it to improve a code. It was stated that perhaps a more equitable distribution commensurate with the importance of these two broad efforts would be relevant.

Reviewer 2:

The reviewer commented that the funding level appears appropriate for the level of work required and planned.

Low-Temperature Gasoline Combustion (LTGC) Engine Research: John Dec (Sandia National Laboratories) - ace004

Presenter

John Dec, Sandia National Laboratories.

Reviewer Sample Size

A total of four reviewers evaluated this project.

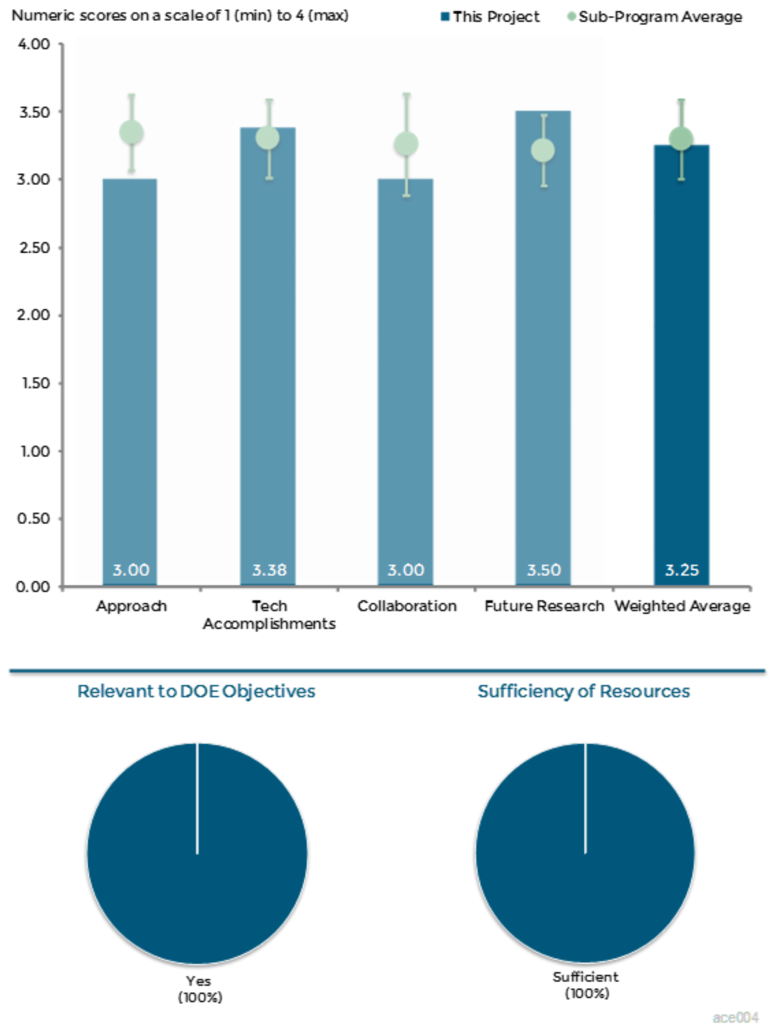

Figure 4-3 Low-Temperature Gasoline Combustion (LTGC) Engine Research: John Dec (Sandia National Laboratories) – Advanced Combustion Engines

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer expressed an agreement that there is a full suite of techniques to address barriers, but suggested that there is a need to add combustion noise to ringing intensity metric as measure of combustion quality.

Reviewer 2:

The reviewer recommended that there should be much more emphasis on SI dilute combustion and to accelerate implantation of dual plug head.

Reviewer 3:

The reviewer indicated that continued improvements in indicated efficiency are interesting, but questioned what the PI expects for brake thermal efficiency considering the high boost pressure on a multi-cylinder metal engine. The reviewer then expressed a concern that the boosting required will be difficult with low temperature exhaust due to the lean mixture and high indicated thermal efficiency.

Reviewer 4:

The reviewer observed a combined effort of single cylinder engine testing and analysis to enhance fundamental understanding of fuel energy distribution in the IC engine process and multi-DI fueling strategies.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer acknowledged that project team has great progress toward further improvements in indicated efficiency. Concerning eventual implementation of the combustion concept, the reviewer questioned what impact will variations in commercially available gasoline have on the engine performance.

Reviewer 2:

The reviewer remarked that there were interesting results related to energy distribution analysis with respect to various parameter sweeps, and added that a knock onset indicator was developed. In addition, double DI partial fuel injection was studied in detail with regards to timing and fueling ratio and the impact on peak thermal efficiency. It was suggested CA50 controls methodology development from such studies are imperative.

Reviewer 3:

The reviewer commented that delaying spark assist; low charge motion cylinder head by a full year, for DI partial fuel stratification (PFS) work, seems long.

Reviewer 4:

The reviewer questioned if ringing intensity is being used as a noise or combustion quality metric, and noted that a comment was made that the project would benefit from a P-diagram to show the control and noise factors and how each is being addressed. The reviewer concluded that this would help understand the long term viability of the approach.

Question 3: Collaboration and Coordination with other institutions.

Reviewer 1:

The reviewer remarked that there is outstanding collaboration throughout AEC, industry partners, universities and national laboratories.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer suggested that the DI-PFS strategies should be tied into a CA50 control strategy from the physical understandings gained from this project, and added that a simple prototype controller hardware can be used in such an investigation or development.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer said that all the fundamental research to understand energy distribution and DI-PFS strategies are crucial to enhancing engine efficiencies.

Reviewer 2:

The reviewer reported that this approach might result in improved engine efficiency, but only if it is proven on a brake basis with a real boosting system.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

There were no reviewer comments on resources.

Spray Combustion Cross-Cut Engine Research: Lyle Pickett (Sandia National Laboratories) - ace005

Presenter

Lyle Pickett, Sandia National Laboratories.

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

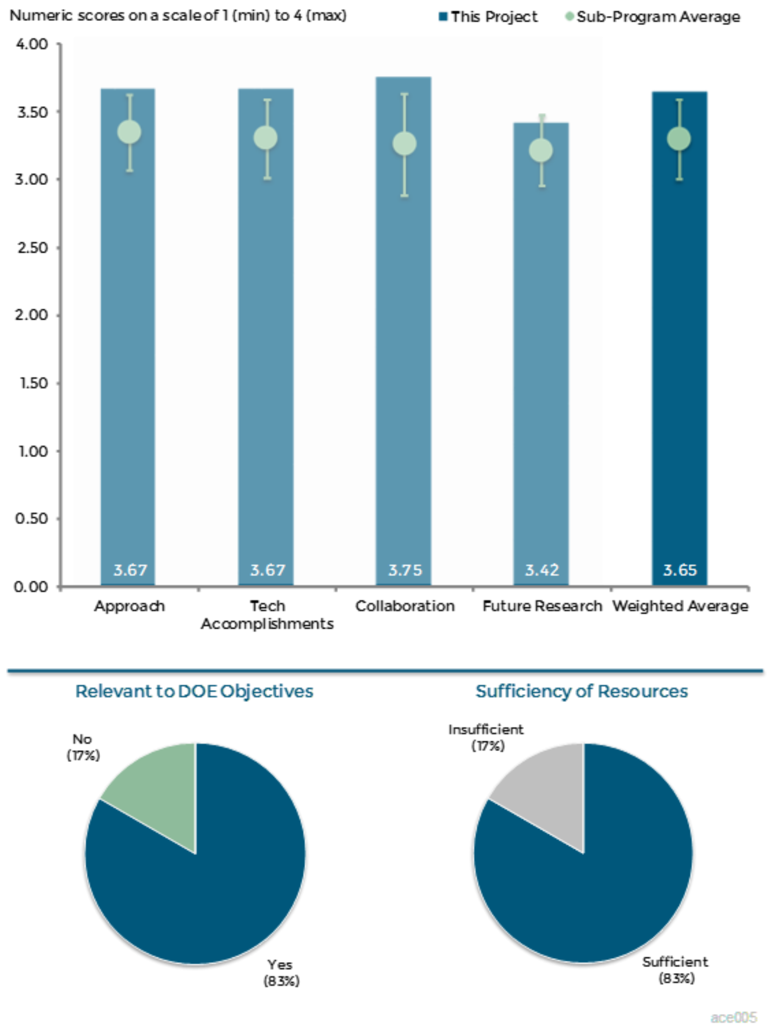

Figure 4-4 Spray Combustion Cross-Cut Engine Research: Lyle Pickett (Sandia National Laboratories) – Advanced Combustion Engines

Reviewer 1:

The reviewer commented that overall, the approach was been excellent utilizing the PI's experimental capability along with those capabilities of various collaborators. There is still much to learn about post injection mixing behavior in light of its potential impact on in-cylinder soot formation and it would be helpful to connect such mixing observations to the formation of soot either or both experimentally or computationally.

Reviewer 2:

The reviewer noted that in many ways, the Engine Collaboration Network (ECN) is a brilliant concept which is a true, non-competitive collaboration that brings together national labs, universities, component suppliers, and engine makers. The ECN multiplies the investment that DOE puts into it many fold. The reviewer mentioned that the research conducted by SNL itself is quite good as well, providing crucial understanding and experimental benchmarks for this key engine technology area.

Reviewer 3:

The reviewer commented that the approach has been methodical and stepwise, progressively attacking unknown features of spray combustion. Past work with spray A has been very organized. The reviewer suggests that there is some challenge evident now with the variety of sprays which are or will be under study. The reviewer then remarked that all of the sprays are important for various aspects of the overall project, but bringing them together and making the findings into a coherent story will be challenging going forward.

Reviewer 4:

The reviewer mentioned that the constant volume high pressure high temperature, while having some limitations, offers some advantages like precise and accurate control of the boundary conditions and initial conditions of the experiment, and suggested that the tradeoff is worthwhile.

Reviewer 5:

The reviewer said that the Principal Investigator (PI) noted the importance of improving engine efficiency which is believed to be gained by understanding direct-injection spray processes at engine-relevant conditions, and the CFD modeling of it. The reviewer then commented that there is little argument that spray quality will impact fuel economy and efficiency, in a broad sense. The challenge, however, is to establish a quantitative link, and this presentation did not do that. The reviewer pointed out that the importance of the approach was cast in more general terms as the need to do experiments at high pressures, understanding of the behavior of liquid in a high pressure environment, the process by which ligaments form droplets and knowing how spray cone angle varies with time. The reviewer also pointed out that all of which are qualitatively important but the quantitative connection to engine efficiency was somewhat deficient. For example, the reviewer questioned how is the gas solubility effect in a liquid fuel (droplet) that accompanies injection into a high pressure gas related to engine efficiency. The reviewer commented that in this reporting period the experimental approach appeared to be to use a constant volume chamber for imaging a spray and some interesting results were presented, and added that the environment of an engine is highly transient though and questioned if there are considerations with the constant volume results that prohibit carry-over to the environment of an engine. It was explained that this presentation would have benefitted mentioning some prior high pressure spray experiments that had been previously reported. Such information would have helped place this study in the context of the prior literature. This reviewer then suggested that asking such questions as what is new, what conditions have been previously examined, and how does the present study extend the prior art would be useful to have answers to.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer commented that the technical accomplishments pertaining toward single versus multi-hole nozzle spray behavior and post injection mixing has been impressive to date. There is still much more work to be done in order to extrapolate these findings to injector design, nozzle choice, and injection timing strategy. This reviewer then suggested that exploring past work on single versus multiple guided needles to better control hole-to-hole spray injection rate profile and to consider the presence of an impingement surface on post injection droplet or blob behavior from a wall wetting or near wall combustion behavior perspective.

Reviewer 2:

The reviewer noted that high-speed photo microscopic movies are very impressive indeed. The behavior of surface tension is very interesting in the transition regime. This reviewer claimed that these data and images will certainly help the modelers. It was mentioned the amount of progress made on Spray G and gasoline sprays was disappointing. The reviewer then questioned what can be done to speed up doing more experiments of interest to industry with Spray G or some other gasoline direct injection spray.

Reviewer 3:

The reviewer observed that the supercritical findings are fascinating, and should be of high interest when viewed in combination with multiple injection strategies for DI engines. The reviewer expressed suspicion that it will take some time before the results are fully interpreted since there is quite a bit there to understand. The reviewer expressed an encouragement for more investigation and discussion of the multi-plume verse single-plume experiments, and mentioned that there is an increasing body of evidence that there is significant plume-to-plume variability which impacts the cylinder performance and emissions, and as CFD results move towards higher predictively and fidelity, understanding how to capture those effects will be of increasing importance.

The reviewer also expressed an interest to see more time and budget devoted to the GDI spray. While there is more decoupling between the spray and combustion in a stoichiometric SI engine, the huge market size and petroleum use of SI means that there is a significant need to push the technology for these engines.

Reviewer 4:

The reviewer agreed that the reported results clearly show that fuel transition from liquid to gas phase under modern in-cylinder conditions is far more complicated than the traditional evaporation construct would suggest. Fortunately, modeling is beginning to catch up, but these descriptions need further quantification and incorporation into the tools that combustion system designers can use on a routine basis (i.e., without recourse to massively parallel computing that still takes weeks to complete one run).

Reviewer 5:

The reviewer remarked that the images showed the apparent disappearance of the liquid/vapor interface. Perhaps the PI can envision more controlled experiments for individual droplets that will allow better access to the multiphase boundary and how it might disappear. This reviewer then commented that a context with the prior literature would help here. The behavior of liquids in supercritical conditions is somewhat known, though perhaps not in the context of sprays. It was brought to light that aspects like increased gas solubility, disappearance of the interface and surface tension going to zero are all known concepts. The reviewer mentioned that it was noted that the ligaments ultimately formed spherical droplets after some deformation and oscillations. This reviewer questioned if these oscillations are more pronounced at high pressure, and if so why. The reviewer noted that it is quite interesting that much was made of tracking some individual hexadecane droplets injected into a supercritical environment (900K, 60bar) ambience. The reviewer asks if the PI can comment about the phase boundary that was apparent in his images. Additionally, this reviewer questioned if the fuzziness was the result of out-of-focus images or was it due to transitions through a supercritical environment where surface tension disappears. The reviewer then pointed out that the challenge with the experiments is how to extract quantitative information from them. It was observed the data obtained were somewhat qualitative, though apparently consistent with some prior published SNL simulations (Dahms and Oefelein, 2013). This reviewer then explained that the challenge is how to fold the results of these experiments into the framework of the ECN, where modeling work is being pursued among the partners.

Question 3: Collaboration and Coordination with other institutions.

Reviewer 1:

The reviewer said that the ECN has been a huge push to the spray combustion community and provides outstanding coordination with a wide range of researchers, engine manufacturers, and suppliers.

Reviewer 2:

The reviewer mentioned that the collaboration appears good in all directions including government, academia, and industry. Additional collaboration with code vendors to get the technology out of the labs and into the commercial tools is encouraged.

Reviewer 3:

The reviewer commented that the engine combustion network continues to be an important collaboration for DI engine researchers around the world. This reviewer said that it is apparent the ECN has been an effective means to amplify the level of understanding pertaining to low and high pressure engine relevant sprays.

Reviewer 4:

The reviewer mentioned that the ECN, by nature of its philosophy, results in very good collaboration.

Reviewer 5:

The reviewer noted that the PI lists industry partners through an MOU, and collaborations with the ECN. This reviewer stated that the issue, if one could call it that, is precisely what is being developed by this project that those in the modeling community will need to validate predictive simulations for high pressure spray injection. The reviewer questioned what are the data and the measurements. It was explained there are some nice qualitative experimental results in this project, and the PI has a good command of the range of simulation capabilities being pursued. The challenge is to convey what the PI is developing that the collaborating modelers will need. The reviewer concluded this point should be strengthened in figure presentations. The reviewer indicated that the PI noted close collaborations that will lead to better CFD tools which presumably will be developed by those listed in the ECN who are pursuing development of no less than seven codes (e.g., KIVA, Converge, RAPTOR, Ansys, etc.). However, there are so many collaborators that it would seem almost unmanageable to work with them as a whole. Almost 30 groups are listed in the ECN, and the PI has noted the importance of his involvement with this group. The reviewer warned that it was not clear what the PI was delivering to the modelers and who among the group is working with the PI to use his data. The reviewer then concluded that this point should be strengthened in future presentations.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer expressed an overall agreement that the proposed future research is logical and provides a means to logically explore post injection mixing in high pressure jets and overall mixing behavior in low pressure sprays, and suggested that the PI consider exploring the impact of nozzle guiding options on hole-to-hole injection rate profile from miscible mixing and single versus multi-hole nozzle perspectives along with the potential impact of wall impingement on post injection mixing processes. The PI may also wish to consider lower chamber oxygen concentrations for future combustion experiments to explore the impact of potential miscible mixing on the combustion event including soot formation.

Reviewer 2:

The reviewer commented that the future work which includes development of a transparent nozzle assembly is interesting. However, the reviewer suggested the PI should scrutinize the literature to determine the extent to which such an approach may (or may not) have been pursued in the past to understand flow in the near nozzle region of a spray. The reviewer noted that an effort to study flash boiling is also mentioned but thought it is unclear what the PI has in mind. The reviewer explained an understanding of this process relies in part on the superheat/super saturation physics of liquids that arise for fluids that are in the metastable state, which also occurs during cavitation processes. It was recommended in future presentations the PI should establish more quantitative connections of how spray quality affects engine efficiency. This is necessary to maintain relevance of the work. This reviewer then indicated that it would require some full scale engine testing to employ things learned from fundamental spray studies to assess fuel economy benefits. The reviewer concluded that the science may be great, but if it doesn't translate to fuel economy gains the work will not have the desired impact for this program.

Reviewer 3:

The reviewer commented that there is a huge amount of work proposed between spray G, spray B, and sprays C/D, but would be concerned that too little will be done on each and that fewer topics with more depth may be better. This then expressed an agreement that all of the future topics are key and understands the balance is difficult.

Reviewer 4:

The reviewer mentioned that, to date, it appears that the focus has been on smaller injectors and it would be interesting to see the same sort of extensive study applied to heavy duty diesel injectors as well.

Reviewer 5:

The reviewer remarked that much more Spray G work needed.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer stated an agreement that this project supports DOE objectives by providing a potential future capability to design fuel injectors and combustion systems that enable combustion modes that ultimately reduce emissions while meeting Government fuel economy standards.

Reviewer 2:
The reviewer acknowledged that a better understanding of the injection of petroleum fuels in internal combustion engines (ICE) will lead to gains in efficiency through better designs and ultimately to reduction in fuel consumption.

Reviewer 3:
The reviewer observed that the PI notes the need to study the problem of engine efficiency from the perspective of gaining a fundamental understanding of sprays, mixing, multi-hole injection processes, pressure effects, and to collaborate with modelers working to simulate in-cylinder processes. This reviewer also stated that, beyond these broad considerations, a stronger link of each to fuel economy should be made. Doing so will assist the work by informing conditions and experiments on spray dynamics that should be performed.

Reviewer 4:
The reviewer noted that, as the PI said, the combustion system is driven by the spray so there is still an enormous need to understand the spray better both for the physical understanding as well as the modeling capability that will follow.

Reviewer 5:
The reviewer questioned if the ECN work is directly relatable to high efficiency engines, and also asked if the models that are being generated with ECN data directly relatable to high efficiency engine research and development. This connection has to be made in a clearer manner. Then reviewer then pointed out that the work is not relevant enough for LD fleet if more gasoline work is not performed.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer expressed a preference to see more funding to allow for more progress on gasoline direct injection (GDI) and conventional DI in parallel. This reviewer commented that the progress given the funding level is very good, but there is so much to do in this project.

Reviewer 2:
The reviewer reported that the collaborative nature of the research means much more results than the dollars going into the project alone can generate.

Reviewer 3:
The reviewer noted that this project appears to have a budget of almost $1 million, but stated that this does seem high given the issues of quantitative measurements noted previously. It was suggested some discussion in future presentations might assist the reviewers to better understand what this funding goes for, given that apparently the PI now has an experimental design up and running.

Reviewer 4:
This reviewer emphasized that the resources seem to be adequate for this type of applied research project.

Automotive Low-Temperature Gasoline Combustion Engine Research: Isaac Ekoto (Sandia National Laboratories) - ace006

Presenter

Isaac Ekoto, Sandia National Laboratories.

Reviewer Sample Size

A total of five reviewers evaluated this project.

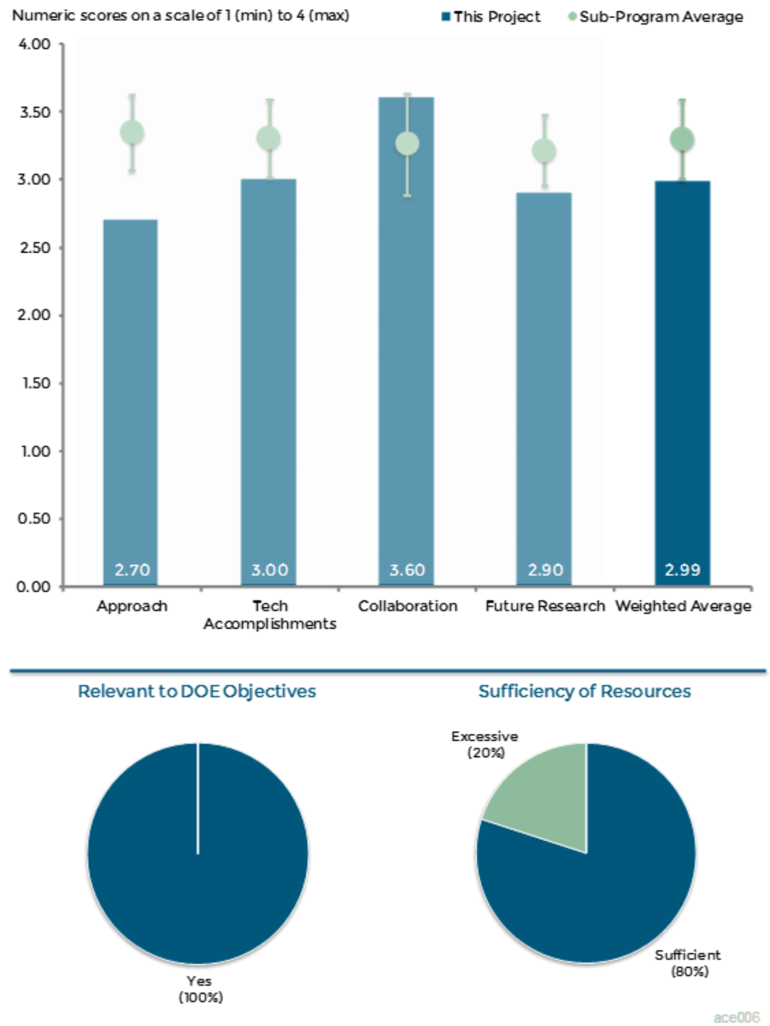

Figure 4-5 Automotive Low-Temperature Gasoline Combustion Engine Research: Isaac Ekoto (Sandia National Laboratories) – Advanced Combustion Engines

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer agreed that multifunctional approach of using optical engine experiments, in cylinder diagnostics, and computer models is very good. It was commented that previous work has been done by others on negative valve overlap (NVO) and spark assisted compression ignition (SACI) and this work does not always seem to be beneficial to improving the viability of low-temperature combustion (LTC). This reviewer noted that it will be interesting to see whether the current work even when completed would significantly enhance the viability or benefits of those approaches.

Reviewer 2:

The reviewer remarked that the approach to analyze in-cylinder reformates created by NVO to enhance combustion is promising with the experimental capability and equipment available at SNL. This reviewer expressed an agreement that future effort on spark assisted compression ignition is an important topic.

Reviewer 3:

The reviewer mentioned that it is good that different fuels and their impact on NVO behavior are being looked at. The reviewer normally thinks of LTC as not having a flame front and commented it seems like a plasma igniter will initiate a flame and questions how this is considered LTC.

Reviewer 4:

The reviewer explained that the approach description is a bit generic making it hard to differentiate from other LTC approaches. This reviewer expressed a need to have more information on other researchers' use of NVO and how this approach differs.

Reviewer 5:
The reviewer pointed out that the barriers that this project claims to address are very broad and would like to see it the project team can be made more specific. The remark was made that this project seems to have many aspects to it and wonders if there is possibility to focus the project more.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:
The reviewer agrees that the progress is generally good with accomplishments that include completion of analysis of NVO end cycle detailed sample speciation data and analysis of the efficiency tradeoff between oxidation and reforming dominated NVO cycles. It was noted that some equipment was purchased for the O-atom laser-induced fluorescence (LIF) experiments.

Reviewer 2:
The reviewer remarked that there has been a good accomplishment of understanding reformate speciation.

Reviewer 3:
The reviewer remarked that there were interesting results from the NVO oxidation and reforming. It was questioned what the maximum load is that the engine can achieve with an NVO valve train. The reviewer commented that energy balance pathways are a good approach to explain behavior. This reviewer also expressed a need to see more results on the ignition system testing.

Reviewer 4:
The reviewer observed that good progress in understanding NVO as enabler for LTC, but indicated that it is not clear what the impact on overall brake thermal efficiency (BTE) or net thermal efficiency will be when this method is employed.

Reviewer 5:
The reviewer commented that it seems like the rate of progress is slow, but questioned what can be done to speed up getting the work done. The reviewer noticed that it has been two years since the ignition work has been proposed, but the old NVO work seems to still be taking up the major effort.

Question 3: Collaboration and Coordination with other institutions.

Reviewer 1:
The reviewer said that it looks like there are collaborations with the three U.S. automakers (GM, Ford, & Chrysler), two lab specialty equipment manufacturers, three universities (USC, University of Minnesota, and University of Edinburgh) and the other national laboratories.

Reviewer 2:
The reviewer mentioned that it is good to see industry involved.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer indicated that future work to determine whether the use of NVO and/or SACI can significantly improve low-load low temperature gas combustion (LTGC) operating conditions is important.

Reviewer 2:
The reviewer mentioned that future work on SACI or laser induced ignition would be interesting to look forward to.

Reviewer 3:

The reviewer commented that it seems like there has been scope creep on this project, but questioned why the particle image velocimetry (PIV) work was added for the Argonne National Laboratory (ANL) ignition modeling effort. Also there is concern the proposed negative valve overlap (NVO) work with the Fuels for Advanced Combustion Engines (FACE) fuels could take up a lot of time. This reviewer then questioned if there is industry interest in doing this work and how the priority for the work is set.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer remarked that the program objective of enhancing fundamental understanding of LTGC processes for development of clean, fuel efficient engines supports DOE objective of improving fuel economy which leads to reduced use of petroleum.

Reviewer 2:

The reviewer indicated that alternative ignition approaches are of interest to industry.

Reviewer 3:

The reviewer said that this project addresses barriers for advanced combustion regimes.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

There were no reviewer comments on resources.

Large Eddy Simulation (LES) Applied to Advanced Engine Combustion Research: Joe Oefelein (Sandia National Laboratories) - ace007

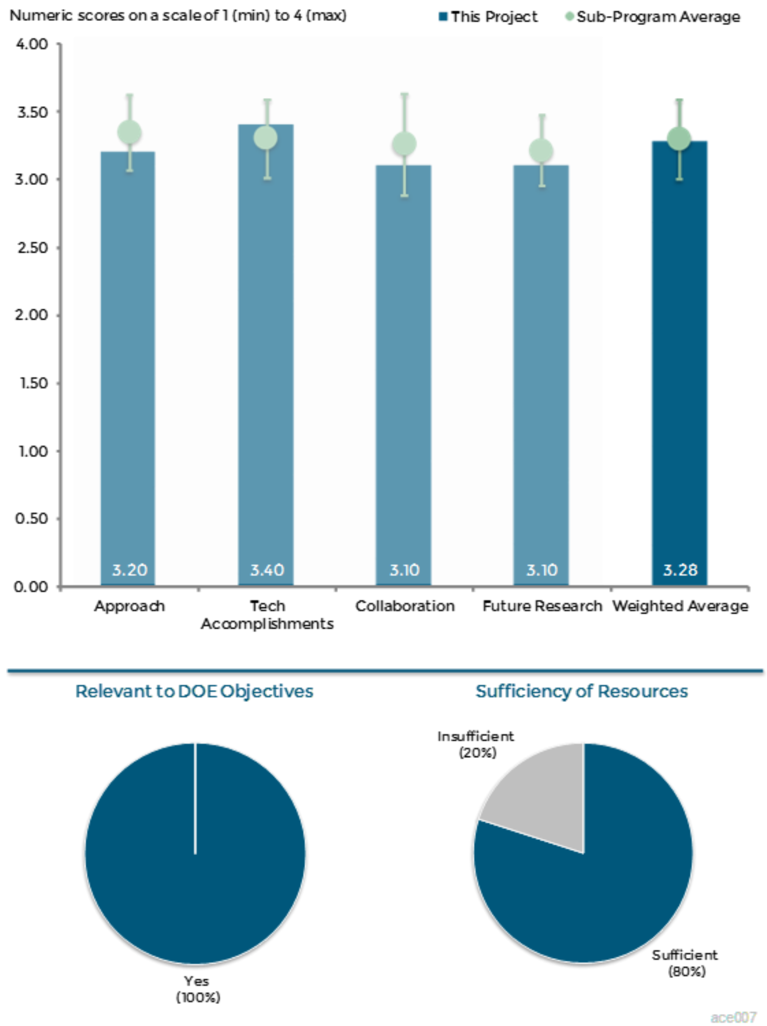

Figure 4-6 Large Eddy Simulation (LES) Applied to Advanced Engine Combustion Research: Joe Oefelein (Sandia National Laboratories) – Advanced Combustion Engines

Presenter

Joe Oefelein, Sandia National Laboratories.

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer indicated that the project and approach are very important. The current CFD codes are useful but still have significant limitations in truly capturing the physics and chemistry of engine combustion. It was indicated the challenge of the project is that by definition it will be well in advance of where it is immediately useful to the industry, which limits its ability to be fully tied into fixing the barriers and having immediate impact on the challenges DOE is addressing.

Reviewer 2:

The reviewer said that the project is interesting work that tackles the issues, particularly with respect to contributions of turbulence, sprays, and combustion from a fundamental standpoint. This reviewer expressed and interest to see more extension into all up engine modeling to see where all this leads, and to see some serious coordination and communication with the commercial code vendors who will ultimately have to produce tools that can make use of this detailed knowledge to improve engineering simulations that actually design better engines.

Reviewer 3:

The reviewer that commented current and past work has focused on free jets at low pressure using constant volume vessel experiments to aid in modeling approach and development, but suggested that it would be helpful to sooner than later attempt using the free jet approach in a real world combustion device that accounts for wall effects and heat transfer. It is recognized that chemistry is still an issue, but the empiricism associated with matching real world engine measurements might end up dominating the end results which is a fair reason to accelerate comparison to engine experiments.

Reviewer 4:

The reviewer noted that this project concerns development of a computer simulation capability for ICEs (the RAPTOR code). It has certain features that separate it from other simulation capabilities (i.e., massively parallel programming; based on a large eddy simulation). The PI noted some challenges such as the high nonlinearity of the equations involved and the multiphase physics that need to be included. The reviewer reported that there is a lot of potential with this approach to simulating combustion engine performance. The reviewer stated that the list of challenges noted in the presentation did not seem to include a potentially important consideration, which is the coupling between in-cylinder transport dynamics and material stresses that are developed as a result of the engine block being subjected to high temperatures and pressures, and transient cycles of these variables during operation, but commented that detailed numerical predictions of in-cylinder processes apparently do not traditionally, but should consider the role of properties of the solid materials that the engines are fabricated from. It was indicated material failure considerations will impact durability and performance. Operation at optimal conditions identified from CFD modeling that neglect a material stress consideration may conceivably only be sustained for limited periods before material failure. The reviewer suggested that some consideration of this matter should be given in the project. The reviewer noted that there are a number of codes currently being developed by other national laboratories (including SNL) for predicting engine performance including Converge, KIVA, Open Foam, Star CD, etc. It was mentioned this project should place RAPTOR in the context of these other codes that ostensibly will claim an ability to predict the same sorts of things that RAPTOR can.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer commented that in terms of project accomplishments within the scope of what it can address, the project has had some fantastic accomplishments. The modeling results which can be tied back to experiments by Musculus and Pickett are hugely exciting and will be a great addition to building the conceptual models of DI combustion. This reviewer concluded that it still appears that the models are well away from simulating a full engine system, so there is plenty of progress still to be had.

Reviewer 2:

The reviewer indicated that, at a fundamental level, there is some great research here, particularly on the role of real fluids during injection, turbulent mixing, and perhaps on the cusp of looking at combustion chemistry. While such a measured approach is good, the ultimate goal should be putting it all together in terms of engine simulations. Once that happens and it is shown to actually produce a better simulation of engine behavior, the scales may tip towards excellent research. The reviewer said that by taking it to the next step and directly impacting engineering level simulations that result in better engine designs, it will move to outstanding research.

Reviewer 3:

The reviewer noted that there has been good progress comparing the free jet direct numerical simulation (DNS) modeling approach with constant volume vessel measurements. These results are limited to free jets at this point in time. Progress has been a little slower than anticipated based on the past five years of work in this general R&D area. This reviewer pointed out that the engine community really needs to see progress made in conducting engine simulations in the near future.

Reviewer 4:

The reviewer highlighted that the work carried out included performing low eddy simulation (LES) simulations for spray A, and thought that spray A is presumably dodecane and spray G presumably means a gasoline spray which apparently was simulated by iso-octane. The data apparently come from constant volume and single cylinder engine experiments. The simulations included multicomponent thermodynamics and transport. The reviewer commented that the PIs are in the midst of carrying out simulations to quantify the effects of wall roughness, heat transfer on nozzle exit conditions, internal injector flow conditions, and are exploring the limits of combustion chemistry. A regime termed cool-flame ignition is noted. The reviewer questions if this is the same as LTC low temperature combustion. This reviewer also questioned how was the CFD regime identified and if the Sarathy, Narayanswami, and Luo kinetics include reactions related to CFD behavior. The reviewer explained that it was not clear precisely how sprays were handled by RAPTOR and asked if it has the capability to resolve individual droplets in a spray. The reviewer also questioned if the internal droplet transport in a spray coupled to the external spray (gas) transport. KIVA apparently provides this level of detail to resolve internal heat transfer within droplets and their evaporation, and their coupling to the region around the droplets. The reviewer questions if RAPTOR has this same capability. The reviewer commented that it is not surprising that there is a wide range of variability of predicted ignition delay times (IDT) between these mechanisms. The differences would appear even larger if the IDT data were presented on a linear scale. The reviewer concluded the more important question is what to do about it and asked if the PI has any thoughts. The reviewer commented the treatment of the GDI sprays was unclear, and then asked how the chemistry was handled, was a surrogate used and, if so, what was it. The reviewer also asked for the PI to please comment on the computational time. In addition, it was questioned if conditions are reached in the simulations where cavitation of flash boiling could occur upon the liquid exiting the nozzle and asked if RAPTOR can handle this situation.

Question 3: Collaboration and Coordination with other institutions.

Reviewer 1:

The reviewer indicated that this project listed an enormous number of collaborators including over 30, either from national laboratories or academia, though the list did not seem to include industry partners. The project should provide more focus to these collaborations to make the team appear to be more focused and credible. Precisely what each of those listed brings to this project was unclear. The reviewer explained it would have been better to have a small number of collaborations that fill specific needs (e.g., data, simulations, sub-models, etc.) and provide specific inputs to the project.

Reviewer 2:

The reviewer said that the collaboration partners include both the ECN and various universities with expertise in engine CFD. This effort did outline utilizing ECN data to validate free jet LES spray formation predictions.

Reviewer 3:

The reviewer noted that there is definitely some good coordination within the government laboratories and with universities, but did not see much direct linkage to engine industry or software vendors to transition the technology and learning to them.

Reviewer 4:

The reviewer observed that this is a tough project for collaboration. The collaboration with other laboratories with complementary efforts is quite good, and it is obvious that other Combustion Research Facility (CRF) researchers are making use of this project as feasible. This reviewer also noted that there is very little collaboration with CFD tool companies and universities which may help to push advanced models towards more wide spread use, or end users. Admittedly, right now the models require computing resources that only the DOE has, so there is not much that could be done by these kinds of collaborators. Today's supercomputer will be a desktop machine in not too many years, so advance coordination now would be good for seeding the understanding of how to use these models. The reviewer suggested that some interaction with the ACEC technical team or some of the modelers at ANL or ORNL (in their engine groups) might be a good way to build those collaborations.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer indicated that the planned next steps look appropriate and are of high value, but would wish for faster progress, even though that is largely tied to computer availability and project funding. The pace proposed fits with those resource constraints.

Reviewer 2:

The reviewer expressed an agreement that the proposed research plan is fair. It would be helpful to pull forward simulation of optical engine experiments as a closer step to simulate metal engine in-cylinder behavior. The reviewer explained that it is not clear how this overall effort compares with LES work at ANL and if there is overlap or duplication.

Reviewer 3:

The reviewer commented that the future work mentioned essentially carrying out a range of simulation cases, including reacting flows associated with a GDI engine. The fuel used will be iso-octane, though ultimately the simulations need to transition to more complex multicomponent surrogates, which introduces a host of issues regarding chemistry and handling of transport properties.

The reviewer noted that other work mentioned includes carrying out LES of combustion to understand internal flow and model validation and in-cylinder simulations for LTC regimes to understand cycle to cycle variations.

Reviewer 4:

The reviewer pointed out that, while there is a lot planned, it looks like engine domain calculations are slated to begin in fiscal year 2017 and 2018 which seems a long way off.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer expressed an agreement that the development of a computational capability for ICEs is, of course, relevant. This project would benefit from placing the development or RAPTOR in the context of other widely used simulation capabilities which ostensibly will make the same claims made in this project regarding high fidelity predictions, low computation time and versatility.

Reviewer 2:

The reviewer mentioned that better understanding of in-cylinder behavior through better simulation methodologies will lead to more efficient engines that burn less petroleum.

Reviewer 3:

The reviewer pointed out that the project is somewhat out there relative to many of the other ones in the ACE portfolio, but this is a key area to invest in to advance our fundamental knowledge of combustion and the tools that will eventually be available for industry to use. The reviewer noted as the work continues and matures; it should support the petroleum use reduction well.

Reviewer 4:

The reviewer commented that this is a fundamental research project currently focused on modeling free jets that ultimately could be linked at a future date to the development of combustion systems most likely in low pressure combustion systems.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented that the project appears to be both limited in funding and progress on the central processing unit (CPU). This reviewer said that if more funding were available, it is apparent that more progress could be made.

Reviewer 2:

The reviewer noted that as a fully computational effort the budget of nearly $500,000 is probably adequate, when scaled with other projects at twice that which emphasize experiments.

Reviewer 3:

The reviewer stated that for the planned effort, the resources appear adequate.

Fuel Injection and Spray Research Using X-Ray Diagnostics: Christopher Powell (Argonne National Laboratory) - ace010

Presenter

Christopher Powell, Argonne National Laboratory.

Reviewer Sample Size

A total of four reviewers evaluated this project.

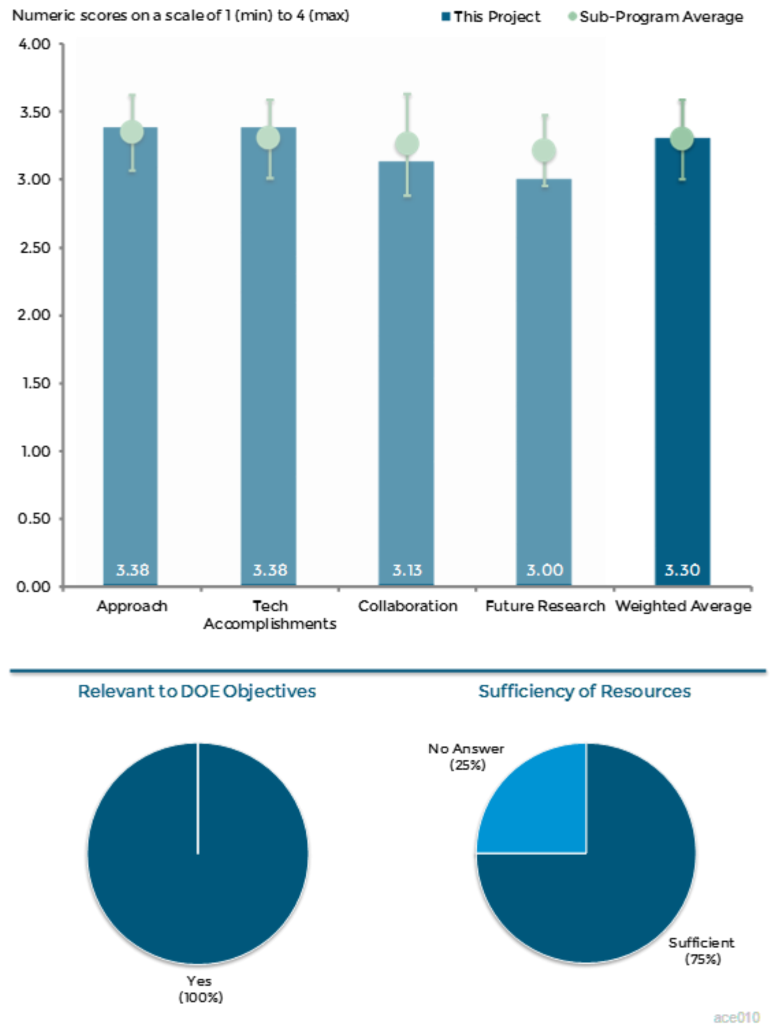

Figure 4-7 Fuel Injection and Spray Research Using X-Ray Diagnostics: Christopher Powell (Argonne National Laboratory) – Advanced Combustion Engines

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer noted that the ongoing development of the x-ray technique is very good. The variability measurement/analysis for the CI spray is very interesting and does appear to have correlation with the mixing process. It was suggested more interaction with SNL on that aspect of the spray investigation would be of high interest to make sure the project team is interpreting the data properly. The reviewer indicated the addition of more GDI sprays is also good. A focus on how the lower pressure/higher volatility sprays differ from CI sprays will be an ongoing area of interest, especially the higher degree of variability in the quasi-steady portion of the spray. This reviewer expressed an excitement by the cavitation measurement capability. This is a long-needed imaging diagnostic. Any efforts which can increase the degree of similarity between the metal injector and the x-ray accessible hardware will be of highest value so that the cavitation measurements will be as valid as possible.

Reviewer 2:

The reviewer said that the application of the APS to study the injection process is a unique capability that is being exploited to better understand the complex physics involved to an extent not possible with other approaches that will be of particular importance in improving simulation capabilities for future ICE development.

Reviewer 3:

The reviewer commented that this project concerns developing an understanding of fuel injection processes to improve efficiency and emissions of engines. The approach involves using ANL's x-ray source to probe the structure of liquid jets in nozzles. This reviewer explained that the tasks are framed around making measurements for various test conditions. The purpose is to develop improved spray models. The reviewer noted that the approach of using the ANL facility is interesting as it provides the means to visualize, through metal, the spray structure. There are alternatives, such as using a nozzle design fabricated from a transparent material, such as plexiglass, for which there is some literature. The future work does mention real pressure transparent nozzle. The reviewer questioned what x-ray transparent means on the slides. The reviewer asked if it is the high pressures that make a transparent nozzle difficult to probe. This reviewer stated that it was not clear that useful information and at reduced cost could not be obtained with a suitable transparent injector design. The reviewer warned that the presentation itself was not clear on precisely what quantitative data was obtained in the reporting period. However, a lot of nice images were presented. The reviewer noted a need to go digging into some recent literature to find it, as well on the models used (e.g., Converge, OpenFOAM, HRM, etc.). This reviewer also noted that future presentations should be clearer on the data of interest and how modelers are using it.

Reviewer 4:

The reviewer encouraged that continued development of methods to evaluate gasoline sprays.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer stated that there appears to be some very good progress on a few fronts this year. The improvements in the GDI imaging are very welcome and should pay dividends in the upcoming year, and noted that further analysis of how to make use of the variability should be of good value for the CI measurements. The cavitation measurements are really good and the reviewer hopes to see even more of this in the next year. The reviewer commented that the idea of imaging the spark is also very interesting. It is hard to tell how much of the ACE funding was devoted to that. It is something that would be of value if the imaging can provide additional information beyond what is available from electrical and visible light measurements. The reviewer suggested that some additional effort towards quantifying the possible value of this technique would be of use so that one can effectively evaluate the idea next year.

Reviewer 2:

The reviewer mentioned that the project has made several significant contributions in the diesel area and now appears to be making equally important measurements for GDI applications. Improvements in capability to make single shot measurements to help understand shot-to-shot variations will be particularly important for both GDI and diesel applications. This reviewer also indicated that expanding measurements to include droplet size will also be very useful, as will the ability to look at opening and closing transient effects.

Reviewer 3:

The reviewer indicated that the accomplishments reported for the past year included a lot of measurements and visualizations for the Army and modelers in the ECN. The PI also mentioned Sauter mean diameter (SMD) measurements. However, from what could be determined no such data were reported. The reviewer asked for this to be clarified. The efforts also involved completing a three-dimensional (3D) tomography arrangement that will allow measurement of the time-resolved density through the spray. The reviewer noted that one of the discoveries is that the spray has a high variability near the start of injection, and asked if this was surprising, and if so, why. The reviewer also wondered if it was the result of gas that may be trapped in the injector. The reviewer remarked the cavitation studies are interesting and was reported by the PI in a 2015 publication, and questioned if the PI has any strategies for reducing dissolved gas and cavitation. The reviewer asked in the simulation what cavitation threshold was assumed (i.e., pressure for a given temperature). The liquid is in a state of tension before it cavitates, and predictions will no doubt require knowing the thermodynamic state of the liquid that triggers cavitation. Also, the cavitation threshold is dependent on the dissolved gas content. The reviewer questioned how the PI's team estimate the dissolved gas content and predict the cavitation threshold. It was pointed out the PI notes contributions of data for the ECN, and asked precisely what data does the ECN need here. The use of the x-ray diagnostics to study ignition is interesting. Presumably it is by spark. The reviewer stated that it would appear to be very important to accurately measure the ignition energy, and suggested that the PI should provide some insights into how this could be done.

Reviewer 4:

The reviewer questioned if the measured spray variability is relevant when installed in a combustion chamber that has charge motion. It was suggested continuing emphasis on tying measurements to higher level engine attributes.

Question 3: Collaboration and Coordination with other institutions.

Reviewer 1:

The reviewer remarked that the collaborative team is impressive including personnel with expertise in experiments and modeling. The collaboration with other colleagues at ANL (that employ Converge simulations) was clear, and noted that the role of the non-ANL collaborators was less well presented. For example, the PI does not state precisely what data are integral for the ECN network. The contributions of the academic partner were not clear on what was provided. Industrial contacts were mentioned but this is vague. The reviewer suggested it would help in future presentations to better show precisely what role the collaborators have. Providing results from the PI's efforts and quantitative input from the collaborators will be beneficial.

Reviewer 2:

The reviewer commented that the ECN interaction is very good, and certainly provides value to the ECN group, but would like to see more interaction with injector manufacturers beyond Bosch for the ANL work specifically. Also, it was indicated interaction with the engine groups at SNL or ORNL may also be valuable; to see how the findings from the APS imaging can be integrated back to the metal and optical engine work.

Reviewer 3:

The reviewer indicated that work with academic modelers and commercial code developers are very good, as is direct work with engine and injector makers.

Reviewer 4:

The reviewer stated that it is important to connect measurements to engine level attributes and encourage work with engine manufacturers/designers to make these connections.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer mentioned that the upcoming plans are very exciting, particularly the shot-to-shot work and the cavitation plans, and reported that both of these should increase the value and relevance of the work.

Reviewer 2:

The reviewer explained that the real fuel data is interesting but it cannot be simulated because one do not know their properties for inputs to validate codes. In particular things like combustion chemistry are not known and estimation methods for thermo-physical properties for real (multicomponent) fuels are not well established. The reviewer said that data for transportation fuel surrogates are more valuable for modelers because their combustion chemistry and physical property estimation methods are available (for judiciously selected gasoline and diesel surrogates). The issue should be important here because the PI notes the need for model validation with ECN partners. The reviewer suggested that the PI should consult Laurence Livermore National Laboratory (LLNL) for suggestions on a suitable surrogate(s) for their continuing work. The reviewer questioned what it meant when the PI stated “generate the temperature.” The reviewer stated that some of the plans for future work are a bit vague. For example, the PI notes the desire to build facility for high temperature sprays. This is unclear. This reviewer then asked if the PI envisions integrating the high temperature facility with the x-ray diagnostics. A clear need should be established here. The reviewer then noted that flash boiling of liquids is mentioned but the PI provides no elaboration on this process. Some of the same thermodynamic considerations involved with cavitation will also be relevant to flash boiling but these are not discussed. The reviewer remarked that the task for validation of LES simulations does not tell us much. The reviewer then questioned whose LES codes is being considered. SNL (Livermore) has a significant effort in this area (the RAPTOR code) but their contribution is unclear, though the PI lists SNL to assist development of improved spray models. The reviewer also questioned what data are needed and what capabilities does the PI have to deliver it. The reviewer commented that the future plan notes that the project team will have further measurements after consultation with experts. These experts are not identified so it is not clear. This reviewer questioned if the experts are part of the team or collaborators to be developed. The reviewer said that remaining challenges are noted that include pre-burn, shock tube, rapid compression machine (RCM) and Engine, but questioned what the PI is referring to here because it is hard to follow.

Reviewer 3:

The reviewer expressed an only concern is that expanding work to include GDI injectors will not adversely affect work on diesels, particularly measurements involving larger injectors used in heavy duty engines.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer said that the project is relevant because sprays set the initial conditions for fuel combustion in engines and this project is investigating the internal flow and atomization process in nozzles.

Reviewer 2:

The reviewer explained that understanding the spray physics is still key to improving both gasoline and diesel engines. The work in this project continues to develop ways to understand the sprays better and is providing new tools which are pushing into areas where there is great uncertainty in the spray physics.

Reviewer 3:

The reviewer stated that understanding injection is a key component in understanding ICEs. This reviewer concluded that better understanding leads to better designs which leads to higher efficiency and hence less petroleum consumption.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer indicated that it seems that the rate of progress and the funding level are well tied together and fit well with the overall program goals and desired rate of progress.

Reviewer 2:

The reviewer stated that resources seem reasonable.

Reviewer 3:

The reviewer said that the costs that are listed as being $775,000 for fiscal year 2015 seem high, but questioned if the costs are high due to costs of running the x-ray facility. The presentation did not give an appreciation for what is involved with such a large expenditure. It was suggested more should be provided to adequately assess this evaluation category.

Use of Low-Cetane Fuel to Enable Low-Temperature Combustion: Steve Ciatti (Argonne National Laboratory) - ace011

Presenter

Steve Ciatti, Argonne National Laboratory.

Reviewer Sample Size

A total of seven reviewers evaluated this project.

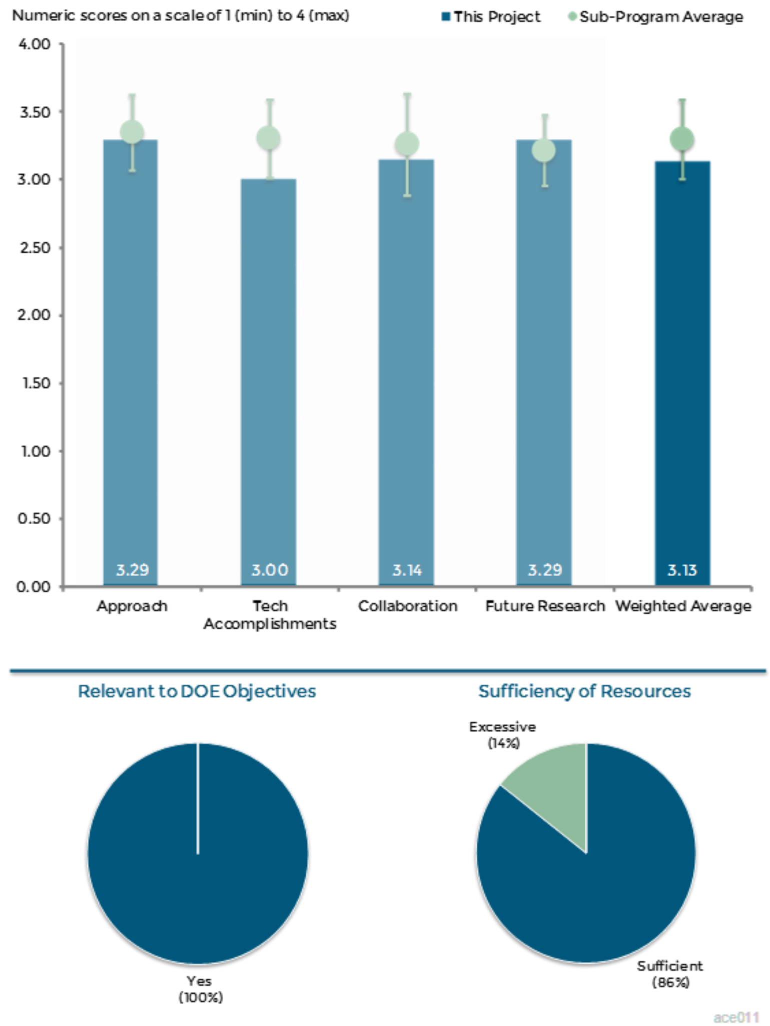

Figure 4-8 Use of Low-Cetane Fuel to Enable Low-Temperature Combustion: Steve Ciatti (Argonne National Laboratory) – Advanced Combustion Engines

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer reported that this project is an excellent combination of experimental and computational tasks. The former experimental work has been excellent to date. The only suggestion is to explore wider engine operating conditions closer to a real engine-transmission combination in a LD vehicle.

Reviewer 2:

The reviewer commented that this is excellent fundamental work to understand gasoline compression ignition in MCE, both experimentally and numerically. It was explained that advanced in-cylinder imaging and simulation work were used to study the auto-ignition process and soot distribution of gasoline compression ignition (GCI). Advanced imaging is a good way to investigate soot particle size distribution and number; it might be helpful to better describe the methods for determining the particle size and number when doing the post-processing of the images. If the results shown on Slides seven and eight for GCI and conventional diesel combustion (CDC) were produced from the same engine, the reviewer questioned if it is possible that the low soot luminosity for GCI is due to the leftover product of diesel combustion (for example, soot from diesel combustion). This reviewer then stated the results on Slide 15 are very encouraging.

Reviewer 3:

The reviewer commented that LTC has promise for significant efficiency improvements. This work provides understanding of the benefits and challenges of one recipe for LTC.

Reviewer 4:

The reviewer remarked that LTC control is with GCI in MCEs.

Reviewer 5:

The reviewer noted that the general plans for the project are good at attempting to address the challenges with GCI combustion. There are some significant holes evident in the approach though, or at least in how it is presented.

The reviewer explained that engine-out and tailpipe-out emissions are key. It is well understood that a GCI engine can be quite efficient. Different combustion approaches can change how much of a challenge hydrocarbon (HC) and carbon monoxide (CO) are, but there will always be emissions and these challenges will always need to be addressed. Beyond the availability or lack of low-temperature aftertreatment, there needs to be continued reporting on the engine-out emissions whenever the efficiency/brake specific fuel consumption (BSFC)/fuel economy is discussed. An estimate of the efficiency penalty to meet Tier 3/LEV III is also critical to fairly evaluate the combustion system. This reviewer also stated it is very unclear why there is so much endoscopic imaging as part of an MCE study. The capabilities at SNL to focus on the combustion chemistry and physics are so much more complete; if imaging is needed it should be funded and addressed there instead of on this project. The reviewer commented that using Autonomie is fine, but if it does not also provide estimates of drive cycle emissions then it is only partially useful; efficiency that the U.S. Environmental Protection Agency (EPA) will not allow on the road does us no good.

Reviewer 6:

The reviewer noted that there is a need to address robustness to noise factors in the research. It seems a key barrier to implementation of the technique is robustness.

Reviewer 7:

The reviewer explained that the tools used in this project are not novel, but similar to those in other projects such as endoscopic imaging of soot, operation of an MCE and simulation work.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer stated that overall, there has been excellent technical progress. The only suggestion is to further study possible use of exhaust gas recirculation (EGR) as a lever to control and maybe widen the operating limits of the engine as indicative of LD type powertrain.

Reviewer 2:

The reviewer mentioned good progress has been made against the objectives of the program. The comparison of soot imaging between GCI and CDC is very encouraging. The reviewer suggested if it has not been done already, it might be helpful to compare the soot emission result from engine testing, and soot imaging first to make sure that they are matched, and then go for the measurement of particle size and numbers. The reviewer observed the results for injection timing and boost study are general. This reviewer suggested that a more in-depth analysis may be needed. It is also very important to show the results of other emissions, such as oxides of nitrogen (NO_x) and unburned hydrocarbons (UHC).

Reviewer 3:

The reviewer pointed out that the comparison of soot between GCI and diesel and the effect of swirl on smoke levels are both very interesting. The reviewer asked whether the "flash bulb or popcorn effect" in the simulation videos be explained because it is not imaged for one combustion cycle. The reviewer noted that the gasoline baseline used was a bigger engine. It is suggested that perhaps a downsizing effect ends up confounding the comparison and there may be a better apples-to-apples baseline available so only the advanced combustion performance can be assessed. The reviewer questioned how it compares when compared to a diesel baseline. Even though this comparison may have been published in earlier work, the reviewer suggests it may be useful to update it with the latest data or map and show the bottom line along with the gasoline baseline.

Reviewer 4:

The reviewer commented that the particle sizing work is good and of value, but a broader investigation of that would be highly valuable. This reviewer questioned if the particulate is all carbon, or does it still have significant solvent extractable fraction (SOF). The reviewer expressed an interested in what is the total PN emission from the engine. Filter soot numbers are not particularly valuable for this combustion system. The reviewer suggests that real particulate matter (PM) measurements per EPA accepted methods would be of higher value for evaluating the different approaches. It was noted there was no discussion of NO_x/CO/HC was presented and stated these should always be part of the discussion for the reviewers so one can see the full emissions picture of the engine. The reviewer indicated that there is a combination of running traditional parameter sweeps and then trying to discuss the results in terms of language that indicates that kinetic analyses or other computational studies were performed, but added that this weakens the presentation of the results and makes it harder to draw conclusions from the results. It was concluded the vehicle fuel economy results are rather meaningless if all of the engines are not meeting the same regulated emissions levels, and which are not obvious.

Reviewer 5:

The reviewer pointed out that there still seems to be a loose affiliation of directionally correct observations without an overall vision or pathway to a goal. This reviewer suggested a need to move past the characterizing phase and develop a pathway to completion. Essentially, the reviewer wants to know what success looks like. The reviewer said that the project needs to address the emissionability of the concept, and asked where the key challenges will be.

Reviewer 6:

The reviewer suggested that this project shares similar scope elements to other ACE projects and it is unclear how the results of these separate projects complimented one another as related to overall ACE subprogram objectives. For example, the GCI and soot particle diameter and particle number studies do not seem very different from those already reported by ORNL. The finding that injection timing and boost affect fuel reactivity has also been reported previously by John Dec and others. The reviewer said it was good to see shift to fuel containing 10% ethanol (E10), but results reported so far for E10 are not new.

Question 3: Collaboration and Coordination with other institutions.

Reviewer 1:

The reviewer praised that the project of excellent teaming with lab, university, and industry partners. This reviewer indicated that it shows improvement from last year by bringing in UW, etc.

Reviewer 2:

The reviewer acknowledged that this project has outstanding collaboration with industry and universities and expressed that the project team did a great job. The reviewer indicated there are good partnerships with UW and University of California-Berkeley and there should be much more interaction with SNL or LLNL to make use of the fundamental capabilities there so that the work at ANL can focus on what ought to be done with an MCE.

Reviewer 3:

The reviewer reported that some limited interaction with auto industry reported (GM) and also interactions with two universities.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that future work is reasonable extension of present study. More work at different engine speeds and loads is very important for an MCE because this will ensure that all the conclusions still stand at high load and speed. High load is pretty challenging for LTC, more results in this area would be very interesting. The reviewer pointed out that another suggestion will be also to look at the effect of compression ratio on GCI engine performance, which may be very helpful for balancing the engine performance, engine control and emissions during engine design. The reviewer indicated that work needs to keep up the pace to meet the advertised milestones!

Reviewer 2:

The reviewer stated that proposed future research is logical. The only suggestion is to continue studies for widening the engine operational conditions.

Reviewer 3:

The reviewer acknowledged that adding EGR is useful for demonstrating a more complete control approach. This reviewer suggested that there should be much more focus on transient performance and full emissions so that the barriers for making a vehicle implementation of the technology can be evaluated better.

Reviewer 4:

The reviewer reported that there is a need to estimate HC and NO_x difficulties including cold start approach.

Reviewer 5:

The reviewer indicated that E10 should be the base fuel going forward. This reviewer also agreed that the planned work on characterizing transient performance with low pressure loop EGR will be very relevant, useful and interesting.

Reviewer 6:

The reviewer commented that it is unclear what distinguishes the proposed work from what has been done or will be done in other projects at other organizations.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer said that this is an excellent project exploring feasibility of DI gasoline for next generation high efficiency low emissions engines.

Reviewer 2:

The reviewer remarked that technology will significantly improve fuel efficiency and thus reduce petroleum dependence.

Reviewer 3:

The reviewer observed that a better understanding of the physical and chemistry characteristics of GCI with the goal of improving the development of high efficiency, low emissions engines supports DOE objectives.

Reviewer 4:

The reviewer commented that this project provides understanding on the benefits and limitations of LTC.

Reviewer 5:

The reviewer indicated that if GCI could be made to work; there should be some petroleum use benefit so there is potential in continuing to work on this technology.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said that there appear to be sufficient resources, but there should be more leveraging of near-parallel work going on at other labs rather than trying to do so many things on this project alone.

Reviewer 2:

The reviewer observed sufficient resources.

Reviewer 3:

The reviewer recommended a review of project resources in relation to the overall ACE subprogram budget and objectives.

Model Development and Analysis of Clean and Efficient Engine Combustion: Russell Whitesides (Lawrence Livermore National Laboratory) - ace012

Presenter

Russell Whitesides, Lawrence Livermore National Laboratory.

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

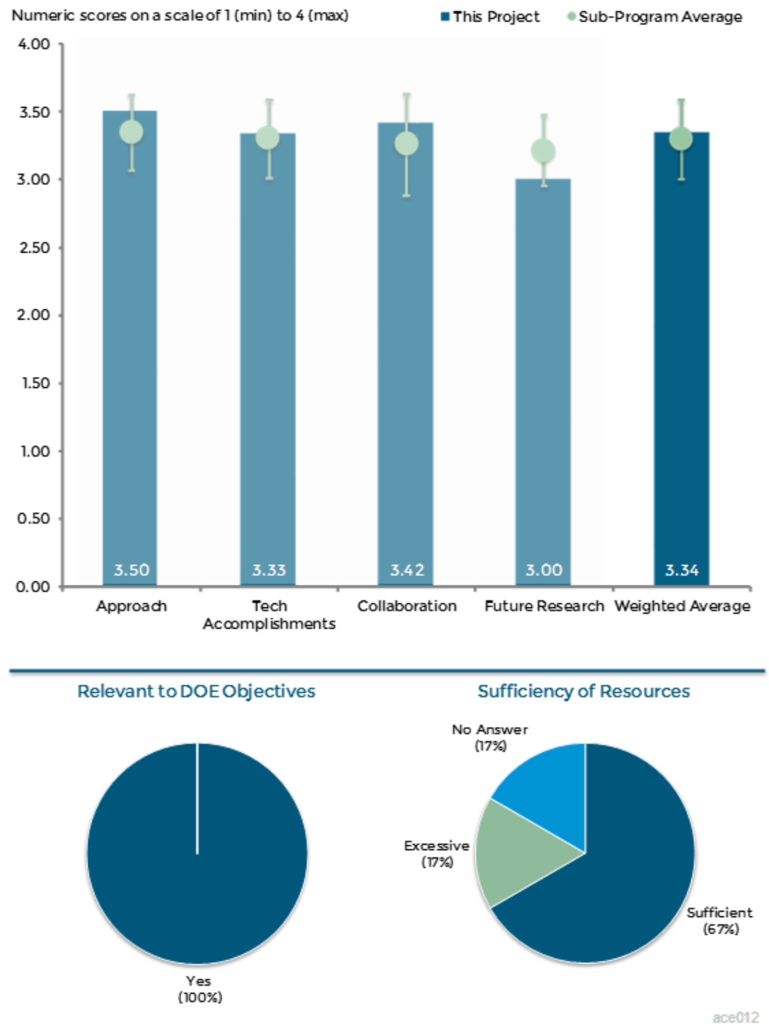

Figure 4-9 Model Development and Analysis of Clean and Efficient Engine Combustion: Russell Whitesides (Lawrence Livermore National Laboratory) – Advanced Combustion Engines

Reviewer 1:

The reviewer explained that, along with other LLNL projects, this work effectively aids the engine simulation community by developing a fast gpu-based chemistry solver for CFD applications. The approach of directly working with commercial code vendors and research code developers gets this technology in the hands of both industrial design teams and academic research groups and is to be highly commended.

Reviewer 2:

The reviewer commented that the work to speed up chemistry computations to enable higher fidelity kinetics as part of CFD is an important task. When this work first began, it was very exciting. At this point it is unclear what the long-term goal for the project is though. The big picture of what real limitations or shortcomings remain is missing. This reviewer pointed out that the uncertainty analysis is interesting, but just running it does not teach much. There needs to be significant work to interpret the results and to show why such a wide range of results could be obtained for a relatively small space of inputs for each variable. It was mentioned depending on the outcome of such an analysis; this could open up a new area of work that could be valuable.

Reviewer 3:

The reviewer indicated that the portion of the project focused on speeding up computational time for chemistry intensive solutions which is great work. The uncertainty example regarding key engine boundary conditions were very good too, but was limited to one medium load operating point. This reviewer suggested that more validation would be helpful in better understanding the predictability of the Converge code while running on advanced speed-up approaches.

Reviewer 4:

The reviewer remarked that the broad purpose of this project is to develop a predictive simulation capability for in-cylinder processes in an engine. The PI will incorporate detailed chemistry in the code. The reviewer pointed out there are several codes currently being developed as noted by the PI including Converge, KIVA, Open Foam, RAPTOR, Star CD, etc. As far as could be determined, the PI is seeking to improve the code's abilities to incorporate large numbers of reaction steps that will make them run more efficiently. This is being accomplished by development of a chemistry solver that could be integrated into the existing codes. The reviewer explained that the presentation appeared to assume that the audience already knew details of the chemistry solver, as the discussion presented results from it without really providing a substantive discussion of its ingredients. It was stated there is some overlap of this project with project ace076 that should be clarified. The reviewer agreed it is very good that the PI envisions bringing a predictive simulation capability to the desktop PC. This reviewer also stated that the success in this project would be significant.

Reviewer 5:

The reviewer questioned if there is a way to incorporate soot emissions in the predictions.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer commented that progress on speeding up computational time frames has been outstanding to date. Validation is still lacking for the convergent code. The illustrative uncertainty example was helpful, but much more work is necessary to better quantify the predictive capability of the Converge code.

Reviewer 2:

The reviewer stated that improvements in computation time eventually enabling calculations to be performed on a PC is good provided accuracy not compromised. Sensitivity analysis to validate model results with experimental results is good.

Reviewer 3:

The reviewer indicated that the approach has been demonstrated and is beginning to be applied to engine simulations. Uncertainty and sensitivity analyses of homogeneous charge compression ignition (HCCI) problem are noteworthy, but commented that the speedup achieved with using graphics processing unit (GPU) is impressive but quantitative comparisons of predictions with using CPU versus GPU should be shown. The reviewer suggested that more validations and comparisons of model predictions with experimental data are needed

Reviewer 4:

The reviewer commented that the work carried out over the past year includes developing simulations (including uncertainty and sensitivity analysis) for a range of in-cylinder conditions, with HCCI and premixed charge compression ignition (PCCI) modes being a focus, and also stated that the PI developed a chemistry interface for coupling to several CFD packages. Converge seems to be the main package considered. The reviewer asked if the PI can please comment if the chemistry solver will be adaptable to KIVA. The reviewer noted that an improvement of between two to four times was noted for some small mechanisms (48 species for iso-octane is mentioned), and suggested that it would help to cast this improvement into actual computational time. The reviewer stated that the emphasis seems to be on smaller mechanisms as it is apparently not cost effective for large mechanisms which are a reasonable perspective. That said, there are other groups which seem to be incorporating large reaction mechanisms in their simulations. For example in project ace007 RAPTOR simulations of ignition delay time were reported using almost 3,000 reactions for dodecane. It was suggested it would help to place the performance of the chemistry solver in RAPTOR or other codes in the context of the chemistry solver being developed here. The reviewer then commented that that perhaps the PI could use Converge to predict ignition delay times from his chemistry solver to compare.

Reviewer 5:

The reviewer stated that it is very unclear from the presentation if the technical accomplishments were a major challenge or not. This reviewer then mentioned that more discussion of what was required to make the speedups and more in depth analysis of the HCCI results are needed.

Question 3: Collaboration and Coordination with other institutions.

Reviewer 1:

The reviewer noted that collaboration with industry partners and universities seems fairly strong. It would be helpful if the engine OEM partner would aid more in validating the Converge code with IC engine data using the various speed-up routines.

Reviewer 2:

The reviewer commented that it is good the PI has on-going collaborations with the AEC working group, several industries, universities and national laboratories. However, what the collaborators provided to the project was unclear, as was the necessity of the expertise of some collaborators, but remarked that for the universities listed (i.e., University of California at Berkeley, UW, Clemson University, and San Francisco State University), there was no information provided on what they were bringing to this project or what substantive contribution they are making.

Reviewer 3:

The reviewer commented that the coordination with other researchers is good, though there are a number of programs all funded in ACE which could be better integrated including, KIVA, high fidelity LES, computational speedup, to make sure that the technologies developed by DOE work together and feed into needed improvements. The reviewer suggested that there also should be some interaction with the end-user industry. Part of the work DOE can be doing is to speed up simulations for what is currently done in industry, but part can also be making the tools faster and better for higher fidelity simulations. Without that interaction, there is little opportunity for impact.

Reviewer 4:

The reviewer reported that the collaboration with code vendors has already been noted, but should be expanded to include more. This reviewer also suggested that while some industrial partners are engaged, more need to be solicited to increase the scale of testing against real engine problems to continue validation and performance testing.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer pointed out that the project listed a number of challenges that will form the basis of future work. These included reducing the cost of CFD, that real fuel (and by that term is assumed to mean surrogate chemistry mechanisms are large and therefore costly so that computational time needs to be reduced, and that it is still an outstanding matter to simulate chemically reacting spray dynamics when soot also forms. More specifically, the future work is framed around broad tasks that will seek to improve combustion chemistry and carry out engine simulations in collaboration with LLNL. This reviewer expressed an agreement that the plan for the future is reasonable, though presented in somewhat broad terms with few specifics. The reviewer suggested that some discussion of the possible overlap or distinction with the future work of ace076 should be provided.

Reviewer 2:

The reviewer said that the proposed future research is fair. It is lacking in experimental validation of the Converge code while running speed-up routines. The reviewer suggested much more effort should be spent validating the Converge code against constant volume vessel and IC engine data.

Reviewer 3:

The reviewer observed that future plans appear a little vague. Hopefully, more work with laboratories to validate, benchmark, and improve the approach while also trying to expand collaboration with engine industry and code developers and vendors is anticipated.

Reviewer 4:

The reviewer noted that the proposed work for CFD speedup looks much like what has already been done and questions what is truly new or left to do. The reviewer said that the uncertainty analysis has some good potential, but needs to be much more defined and much more detailed in execution/analysis.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that from a broad perspective this project involves developing a tool (chemistry solver) that will improve the ability to simulate performance of combustion engines. The particular approach of this project focuses on developing a chemistry solver that will more efficiently incorporate detailed chemistry in various engine simulators (e.g., Converge, KIVA, etc.). This reviewer also explained that since combustion chemistry is an important consideration in detailed modeling of engine performance, so too is development of tools that will efficiently solve the plethora of species diffusion equations that result from considering oxidation schemes that involve many reaction steps.

Reviewer 2:

The reviewer concluded that if the project is successful and gets faster chemistry into industry hands, then it should assist in developing higher efficiency engines.

Reviewer 3:

The reviewer explained that the project is relevant in so much as improved analysis capabilities will lead to improved engine designs with higher efficiencies and lower fuel consumption.

Reviewer 4:

The reviewer pointed out that this project can provide engine designers with a tool to develop tomorrow's future efficient engines.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that resources appear adequate.

Reviewer 2:

The reviewer pointed out that the results presented do not appear to be consistent with the amount of funding provided. This could be because the difficulty of the task is hard to appreciate but that needs to come across in the presentation.

Reviewer 3:

The reviewer explained that as a project that emphasizes simulation (without an experimental component) the budget at about $500,000 is in line with other studies of this type. However, the reviewer suggested that the results of the project should be reviewed in relation to project ace076 in terms of their combined contributions to ACE subprogram objectives.

Chemical Kinetic Models for Advanced Engine Combustion: Bill Pitz (Lawrence Livermore National Laboratory) - ace013

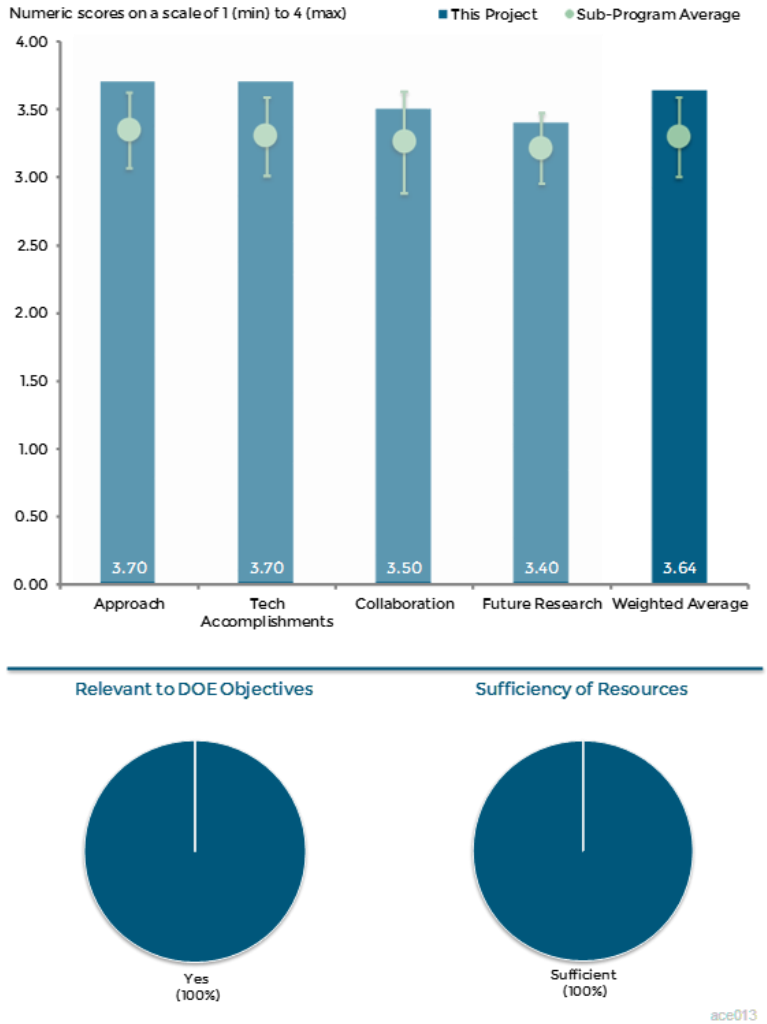

Figure 4-10 Chemical Kinetic Models for Advanced Engine Combustion: Bill Pitz (Lawrence Livermore National Laboratory) – Advanced Combustion Engines

Presenter

Bill Pitz, Lawrence Livermore National Laboratory.

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer observed that the approach for development of kinetic combustion models for key components present in gasoline, diesel and biofuels; combining them to form surrogate fuel mixtures; and development of reduced mechanisms and validation against experimental data from shock tube, rapid compression machines and jet-stirred reactors is extremely valuable.

Reviewer 2:

The reviewer noted that detailed chemistry mechanisms for fuels are the starting points for multi-dimensional engine simulations (granted there is a lot that has to happen, for example, mechanism reduction, before the mechanisms can be used, but still the detailed chemistry is the logical starting point). This reviewer added that the project has made significant contributions through their systematic development efforts over the years.

Reviewer 3:

The reviewer mentioned that this is critical work to improve the state of the art in engine simulation.

Reviewer 4:

The reviewer stated that development of kinetics models for engine fuels is important for combustion modeling purposes. There is also a need to bridge the gap between the chemists and the engine researchers though interactions and workshops. Maybe that needs to be added to the approach of this effort so that the scientists on both sides have a better understanding of what needs to be done and what can be done. Depending on the spatial and temporal resolution necessity of combustion CFD, the chemists can quickly bridge the gap between the fundamental detailed reaction mechanisms and reduced kinetics which can be modeled in a 3D CFD environment in a realistic CPU time.

Reviewer 5:

The reviewer observed that the approach is good, and agreed that chemical kinetic models are needed to aid in chemistry-based combustion calculations. Mechanisms are first validated against available shock-tube or RCM data, which is the best one can do.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer noted that outstanding progress in developing mechanisms for new components and assembling into more robust models for surrogate gasoline and diesel fuels. Accomplishments include: improved low-temperature mechanism for n-butylcyclohexane and validation against shock tube data; development of mechanisms for seven of the nine components present in one of the Coordinating Research Council (CRC) Project 18 under the Advanced Vehicle Fuels/Lubricants of the Coordinating Research Council (AVFL-18) surrogate diesel fuels; development of a cyclopentane mechanism (one of the model components in gasoline surrogates); and development of a 10 component surrogate to match properties of CRC FACE gasolines.

Reviewer 2:

The reviewer commented that it was good to see additional component models for gasoline surrogates. This reviewer also praised the project team's great progress on additional component models.

Reviewer 3:

The reviewer pointed out that there was significant progress demonstrated in fiscal year 2015 in developing kinetics models for gasoline and diesel surrogates. These mechanisms were valid at 40 bars, which is a great progress. This reviewer then commented that the path to higher pressure kinetic calibrations seems to be undetermined. Much higher pressures are routine in ICE combustion.

Reviewer 4:

The reviewer indicated that good progress has been made in modeling several key diesel and gasoline mechanisms.

Reviewer 5:

The reviewer explained that getting mechanisms faster would be better, but it is ultimately more important to get the mechanisms right, so understand the progress can appear slow when in fact it is proceeding as fast as practicable.

Question 3: Collaboration and Coordination with other institutions.

Reviewer 1:

The reviewer observed that the collaboration with industry, the national laboratories, and universities are outstanding. Unlike other projects, the collaboration with industry goes well beyond the two AEC MOU meetings per year, through active, regular engagement with the energy company and automaker members of the CRC AVFL Committee and FACE Working Group.

Reviewer 2:

The reviewer stated that the level of collaboration is extremely high as expected from a national laboratory. The project team is working together with all the stake holders in industry, universities and other national laboratories.

Reviewer 3:

The reviewer reported that good collaborations with other institutions to access raw data.

Reviewer 4:
A reasonable variety of collaborations with other laboratories, universities, and industrial partners is noted by the reviewer.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer indicated that there are excellent plans to continue the outstanding progress that has been made and to continue to advance the program goals.

Reviewer 2:
The reviewer explained that the proposed work logically builds and expands upon the work performed to date. This reviewer suggested that it would perhaps be useful to see more validation against engine data and case studies where industrial CFD users make successful application of the mechanisms developed so far (after appropriate reduction, etc.).

Reviewer 3:
The reviewer commented that future work is progressive towards overcoming challenges. It would be great to see some ICE CFD results using the reduced and detailed kinetics developed in this project, and a comparison with CFD where such accurate mechanisms were not available.

Reviewer 4:
The reviewer suggested that the work planned for modeling and validating gasoline surrogates is much needed and this work should be accelerated.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer pointed out that accurate kinetic mechanisms that are validated against experimental data is critical to successful design of improved, higher efficiency conventional and advanced combustion engines, which will lead to significant fuel economy improvements and lead to less petroleum usage.

Reviewer 2:
The reviewer remarked that better mechanisms supports better simulation which supports better, more efficient, engine designs which reduce petroleum consumption.

Reviewer 3:
The reviewer explained that chemistry models are fundamental requirements to improve engine simulations to design new engines that are more efficient.

Reviewer 4:
The reviewer responded that the project certainly supports DOE and agreed that developing accurate understanding and models of combustion kinetics is paramount to developing pathways to higher engine efficiencies.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer that appear adequate.

2015 KIVA-hpFE Development: A Robust and Accurate Engine Modeling Software: David Carrington (Los Alamos National Laboratory) - ace014

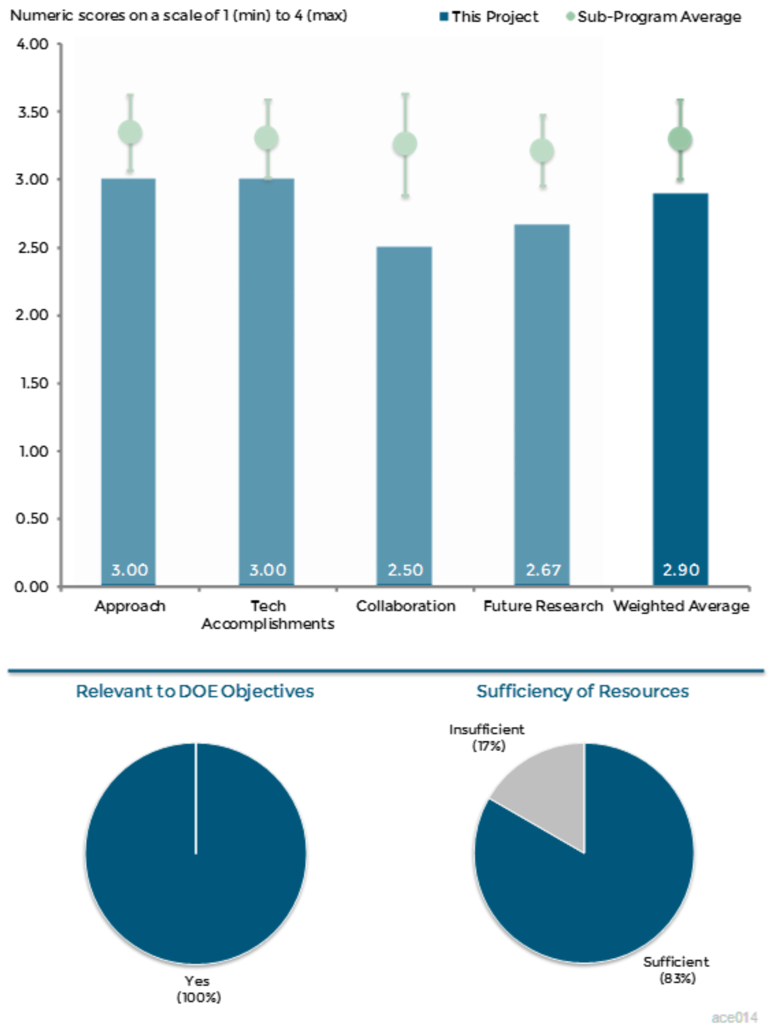

Figure 4-11 2015 KIVA-hpFE Development: A Robust and Accurate Engine Modeling Software: David Carrington (Los Alamos National Laboratory) – Advanced Combustion Engines

Presenter

David Carrington, Los Alamos National Laboratory.

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer indicated that the approach of further improving KIVA to make more robust and accurate predictions of fuel injection, fuel-air mixing and in cylinder combustion and emissions processes is very important.

Reviewer 2:

The reviewer observed that KIVA hpFE is a significant departure from previous finite volume codes. One clear advantage of this approach is in conjugate heat transfer calculations with surrounding walls of cylinder, head, and piston which can be calculated as one integrated analysis without recourse to heat transfer coefficients. The team appears to be incorporating higher order numerics for greater accuracy and working towards a code optimized for high performance computing (HPC) performance. Some improvements in physical modeling over existing codes also appear to be included. The reviewer warned what is missing is how all of this will get in the hands of engine designers who need well supported commercial tools, not research codes.

Reviewer 3:

The reviewer agreed that the approach has been fair, which is aimed at both addressing user issues with KIVA and improving meshing with overall computational efficiency of this legacy code, but explained it would be helpful to see more validation of suggested improved sub-models such as spray modeling, heat transfer, and turbulence modeling from either constant volume devices or engines as appropriate.

Reviewer 4:

The reviewer questioned what can be done to make KIVA more relevant to industry. At present, it really only used in academia and not in industry, but explained it is a good teaching and learning tool to develop student skills in CFD code and usage.

Reviewer 5:

The reviewer pointed out that it is very clear that the project team and lead is vested in enhancing and developing a next generation KIVA code capable of parallel processing and stated the cause is noble. However, it is unclear if this is a good roadmap to developing ICE CFD codes. Industry requires software support from commercial vendors, which national laboratories and universities cannot provide for open source or publicly funded CFD codes. Grid generation techniques eventually should be managed by commercial vendors even if early mathematical development is with laboratories and universities. Thermodynamic, fluid dynamics, and combustion models are where labs and universities can bring in a lot of expertise and validation. Even with those, a commercial spin-off is necessary to provide a support infrastructure and business which laboratories simply cannot provide. It seems there are quite a few leading ICE CFD vendors where a collaborative work could be the future. However, the reviewer expressed doubts about the approaches and accomplishment of this Los Alamos National Laboratory (LANL) led KIVA team.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer stated that technical accomplishments demonstrated by standard CFD problems with the new KIVA code is excellent, including ability to do conjugate heat transfer, without requiring heat transfer coefficient calibration, and also computing speedup with parallelization. The reviewer wondered if the KIVA team will be up for leading a benchmarking effort for a rather simplistic ICE CFD example problem, against other popular commercial code. It was explained that it will be beneficial for the community to understand the pluses and minuses of various codes' capability, and also provide insight into areas where KIVA stands out. Currently that comparison is very subjective, and as a result code choice is based on personal preference rather than rational technical comparison.

Reviewer 2:

The reviewer noted that there appears to be very good progress. Notable accomplishments include better finite element model leading to better KIVA multi-spray model, more accurate droplet transport model and more accurate prediction of conjugate heat transfer in wall film and its effects on combustion and emissions.

Reviewer 3:

The reviewer mentioned that some of the technical accomplishments, like conjugate heat transfer, the ability to track error, etc., are very impressive. However, the reviewer commented rate of progress seems slow. Slide four shows it has been at least five to six years of KIVA-4 development. This reviewer then questioned if the technology is ready for release.

Reviewer 4:

The reviewer indicated that the code speed-up portion of the technology accomplishments discussion was evident. It was claimed that overall the spray model and heat transfer models were improved over the standard KIVA code though there was no evidence presented to substantiate those claims. This reviewer also questioned if the PI has compared the most recent KIVA code to actual spray chamber measurements or optical engine spray measurements.

Reviewer 5:

The reviewer pointed out that progress continues to be steady, but rather slow, but would have hoped that the code would be churning away demonstrating its superiority on real engine problems by now. The project is nearly over and the real validation work has yet to begin. To put it another way, many of the experimental projects are also developing new diagnostics technologies, but the project team is also applying them to answer questions concerning the physics of engine operation in existing and new regimes. One would expect that this project should be doing likewise.

Reviewer 6:

The reviewer stated that it is good to see improvements to grid generation. This had been a significant impediment to productivity in the past. Implementation of conjugate heat transfer is a very powerful addition.

Question 3: Collaboration and Coordination with other institutions.

Reviewer 1:

The reviewer noted that partners and collaborators are mainly limited to co-developers which may be appropriate for this activity at this time.

Reviewer 2:

The reviewer pointed out that the team consists of LANL and a handful of universities, and questioned where the industrial partners are testing the code and its features on real world engine problems. The test cases to date, while important for validating the coding and methodology on comparatively simple, well defined problems, lack the real world engine problems that the code is ostensibly being designed for. Industrial partners would be very good in supplying real problems that need to be solved, giving the code a real workout for its intended purpose. The reviewer asked where the coordination with other government laboratories is. The proposed inclusion of LLNL's chemistry solver technology is a step in the right direction, but is lagging commercial software developers even on this point. Of course, the ultimate collaboration and coordination should be focused on getting this software and its technology out of the national laboratory and into the commercial software vendors who can turn it into the supported, easy-to-use tools needed by the engine industry.

Reviewer 3:

The reviewer warned that collaborations are limited to other CFD developers. This reviewer also suggested that it would be good to see some collaboration to validate CFD predictions with experimental results from engines.

Reviewer 4:

The reviewer noted that there has and is currently collaboration with a couple universities. It is questioned if it is possible other U.S.-based entities are interested in this current work effort who can aid in validating these recent changes to the various KIVA sub-models.

Reviewer 5:

The reviewer suggested that more collaboration or connection with other universities and national laboratories is required to understand why some of them have moved away from KIVA.

Reviewer 6:

The reviewer questioned that if the needs of industry are being considered and why industry is not using KIVA 4 and KIVA hpFE much.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer remarked that the future goals set are very impressive as were the accomplishments this year. This reviewer also warned that some more synergy is required with other teams (including commercial vendors who are working closely with national laboratories to develop physical model). This reviewer expressed a concern about double work in the community. It is suggested that benchmarking leading codes with KIVA and presenting those results will help.

Reviewer 2:
The reviewer noted that the computational aspects of the proposed future research are very good. It is suggested more experimental validation should be part of future research to substantiate improvements to the various sub-models, including constant volume vessel and IC engine spray measurements.

Reviewer 3:
The reviewer acknowledged that plans seem to build on existing accomplishments and directed toward achieving program objectives.

Reviewer 4:
The reviewer recommended that the focus should be on business model of the latest KIVA versions so industry finds it attractive to use.

Reviewer 5:
The reviewer said that because the project is nearing completion, and a lot of development and a great deal of testing (with specifically engine problems) remains, the reviewer questioned if the timeline is realistic given the scope of what needs to be done.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer stated that the development of improved simulators to model fuel injection, fuel-air mixing, and combustion and emission processes that are viable for use by the OEMs should enable faster development and commercialization of more efficient, lower emissions engines, which are consistent with DOE objectives.

Reviewer 2:
The reviewer commented that better analysis techniques will lead to better engine designs which lead to higher efficiencies and less petroleum consumed.

Reviewer 3:
The reviewer agreed that this project does support DOE goals by supplying engine designers with a potential tool to development future fuel efficient ICEs.

Reviewer 4:
This reviewer mentioned that KIVA is the hallmark of fundamental engine modeling. Its contribution in understanding engine physics is unquestionable.

Reviewer 5:
The reviewer stated that the project is relevant. However, this reviewer questioned if KIVA 4 and KIVA hpFE have a future. In addition the reviewer asked if it has been released, who are its customers and what the plan for support is.

Reviewer 6:
The reviewer explained that KIVA is not significantly used in industry, so it does not have a direct impact. However, there is an indirect impact in training CFD developers and users that can contribute to development of codes used in industry and for this reason it is important.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer warned that it will be a close call if everything can be delivered with the resources available, but willing to give the team the benefit of the doubt.

Reviewer 2:

The reviewer explained that to develop a user friendly code for engine design engineers; it appears that the human resource of KIVA is limited. Maybe a private partnership is required to retain the KIVA leadership in fundamental engine modeling.

Stretch Efficiency for Combustion Engines: Exploiting New Combustion Regimes: Stuart Daw (Oak Ridge National Laboratory) - ace015

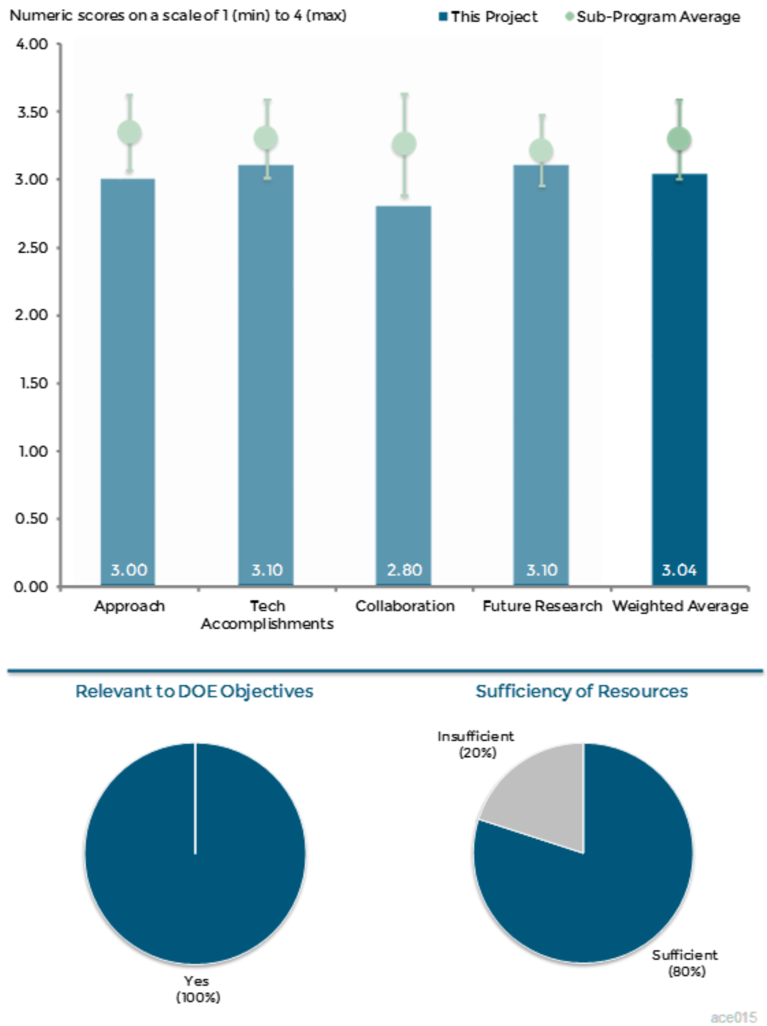

Figure 4-12 Stretch Efficiency for Combustion Engines: Exploiting New Combustion Regimes: Stuart Daw (Oak Ridge National Laboratory) – Advanced Combustion Engines

Presenter

James Szybist, Oak Ridge National Laboratory.

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer mentioned that the experimental efforts on the modified engine, and the associated reactor bench to understand fuel reforming required for this exhaust energy recuperation approach is very interesting. There are other similar projects, but this effort is certainly pursuing some good angles. This reviewer expressed looking forward to the catalytic EGR loop engine tests, if that would drastically improve reformates percentage to enhance combustion in the power producing cylinders.

Reviewer 2:

The reviewer commented that this is an innovative approach to waste heat recovery. This reviewer also pointed out that this work is a good pre-competitive type of research and even more so considering the modest budget of $300,000.

Reviewer 3:

The reviewer explained that this project broadly involves using thermodynamic analyses to identify strategies for improving engine efficiency, and experiments to test the viability of the concepts identified. The team has apparently been using thermodynamics analyses for this end for the past 10 years. The project is pursuing two approaches: reaching the requisite temperatures for reforming in a deactivated piston or employing a catalyst in an EGR system that could promote fuel reforming to produce a sufficient quantity of hydrogen (H_2). For in-cylinder reforming, presumably that piston would provide no contribution to the overall work output in the normal sense and, thus, to fuel economy. Interestingly, there is some evidence that EGR dilution can offset the efficiency penalty of cylinder deactivation. The reviewer suggested that his is unorthodox, and indicated in the most recent efforts the PIs are investigating strategies for utilizing the exhaust waste heat to offset system irreversibility by recovering work, and thereby leading to improved engine efficiency. The reviewer observed that the particular approach here is to utilize the excess exhaust heat to promote steam reforming of fuel as a source of H_2 to allow the dilution limit to be extended prior to combustion instability. The H_2 would come from a sort of sacrificial piston in an MCE or externally in an EGR with a suitable catalyst and partial oxidation. The reviewer commented the source of the water (H_2O) was unclear and asked if it comes from the complete combustion of the fuel and is there enough H_2O naturally present in the exhaust stream to meet the supply of H_2 required. The reviewer remarked that the PIs note that about 20% of system losses come from brake work and exhaust waste heat, while about 80% is associated with system irreversibility of friction, coolant and other sources. The reviewer asked that the team please provide some logic of why their focus is on the 20% and not the 80%. This reviewer concluded that it would seem that more is to be gained by working to reduce a large contribution than a small one.

Reviewer 4:

The reviewer explained that increasing engine brake thermal efficiency has always been a major and challenging task for combustion engine specialists. In this direction, reforming for combustion engines utilizes steam reforming technology for converting waste gases into a source of energy. The authors' research of reformate, dilute combustion through thermochemical recuperation (TCR) is an innovative approach, showing that on-board production of H_2 may decrease fuel consumption under certain conditions. Their two proposed parallel approaches (in-cylinder and EGR-loop reforming) are definitely appropriate within the DOE's research requirements of new, more efficient combustion regimes, but with a high-risk approach, given the H_2 direct utilization on the engine. The intention seems to be in the right direction but, because on-engine testing has not been developed or demonstrated yet, there are still many experimental barriers to overcome towards building an entire flexible engine platform. The lack of any analysis results would seem to indicate that this is primarily a hardware driven program. This reviewer indicated that as comments last year suggested, CFD would be a powerful tool to understand and improve the concept.

Reviewer 5:

The reviewer pointed out that 30% EGR engines has already been demonstrated. One of the unintended consequences of improving engine efficiency is that exhaust temperature is reduced, thus reducing the opportunity for waste heat recovery. EGR Loop Reforming looks a lot like Dedicated EGR from Southwest Research Institute. This reviewer agreed that the catalyst development in a lab environment is a great idea prior to engine testing. The reviewer asked why send exhaust back into a cylinder for fuel reforming. Nissan presented a paper at a Society of Automotive Engineers (SAE) Congress showing an EGR loop fuel reforming catalyst.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer stated that the technical accomplishments are excellent from the reactor bench tests and fundamental understanding of fuel reforming process. Aggressive insulation to increase in-cylinder reforming temperatures should have been addressed quickly, which seems like a shortcoming that can be easily addressed in an experimental setup. The efficiency improvement seems to be only slightly better than cylinder deactivation.

Reviewer 2:

The reviewer commented that the project team has produced an engine platform that is flexible enough to accommodate in-cylinder reforming evaluation and external EGR reforming. The project team identified a barrier to reforming, namely low apparent temperatures. This reviewer then pointed out that it was hard to follow how the various tasks contributed to the ultimate goal of demonstrating the viability of EGR or cylinder deactivation as viable approaches for steam reforming. Experiments to measure cylinder pressure and evaluate performance of a catalyst for EGR reforming were reported. The reviewer highlighted that in basic experiments to identify conditions required for reforming it was found that temperatures on the order of about 1000°K are required, while the thermal conditions for reforming in one cylinder apparently are not sufficient to reach that level (Slide 12). The project team is investigating the possibility to increase temperature by redesigning the exhaust manifold, but proposals for alternative manifold designs were not clearly presented and costs for the proposed designs not discussed.

Reviewer 3:

The reviewer indicated that the project team showed fuel consumption benefits along with improved reforming under lean operating conditions, meaning low and part loads, but questioned what happens at high loads. Having a modified, dedicated low-cylinder-number intake manifold will still be able to provide the high, required flow to sustain high loads. There are many reasons for which numerous engine manufacturers still consider on-board reforming as impractical. Perhaps the project team should explain or investigate what are the overall effects, for example improved fuel efficiency over loss of rated engine power. Also, Slide 15 shows one efficiency reformed-based point but the reviewer did not see a plot showing a trend of DOE’s required stretched efficiencies using this reforming approach. The reviewer suggested that perhaps a plot showing more such points would help.

Reviewer 4:

The reviewer expressed an interest in what aftertreatment strategy would be expected to work with a lambda = 1.1 exhaust products.

Reviewer 5:

The reviewer asked if a favorable operating condition for reforming includes a lean condition, does that imply lean aftertreatment for a production, emissions compliant, implementation of this technology.

Question 3: Collaboration and Coordination with other institutions.

Reviewer 1:

The reviewer indicated that the level of collaboration is excellent too. Comparative analysis with other similar projects approaches and results is always beneficial to ground the audience with regards to the baseline and advances and limitations of such novel approaches. This reviewer also suggested that a slide on that should be included in the next review.

Reviewer 2:

The reviewer agreed that there are good collaborations with academic experts in key areas, but additional collaborations needed with industry to help guide the project.

Reviewer 3:

The reviewer acknowledged that the project team, while accomplished, does not include an industrial stakeholder in the engine manufacturing community to give some credibility to the concept of steam reforming within the environment of a deactivated piston/cylinder in an MCE. This reviewer also warned that there could be some concern if industry would not accept marketing engines in which one of the cylinders was deactivated or essentially not used to produce power but rather to serve as an environment to promote steam reforming.

Reviewer 4:

The reviewer noted that the project team is leveraging knowledge and expertise at other laboratories and universities, but industrial collaboration appears to be lacking. Bringing in some additional resources to do CFD work would undoubtedly prove useful.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer explained that the future work plan seems mostly about continued testing, though with specific conditions not especially well defined, it seems broadly reasonable. Parametric investigations of in-cylinder reforming, which is vague, will be pursued. In addition, more work on catalytic EGR loop reforming will be pursued, albeit it is vague.

It was suggested that future work should include efforts to bring onto the team an engine manufacturer. If the PI cannot convince the engine industry that the approach is viable and the industry has little interest in pursuing the concept, the work would not be worth pursuing.

Reviewer 2:

The reviewer commented that of acute interest will be the transition from the bench flow reactor experiments to on-engine testing, to further study the operation, durability and performance of the rhodium (Rh)-based catalyst.

This reviewer also indicated that because a non-firing cylinder penalizes friction, the question arises if there will be an ultimate benefit of in-cylinder reforming.

Reviewer 3:

The reviewer appreciated that this project is looking at unconventional approaches. There is a need to continue to focus on how the interesting chemistry effects can be leveraged to improve engine efficiency.

Reviewer 4:

The reviewer indicated that the path forward looks good. External catalytic reforming should enhance the results. It is required to establish an H_2 concentration target for the engine to enhance combustion and heat release. Another reviewer questioned if that can be quantified. The reviewer questioned if an application to heavy duty is possible also.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer pointed out that increasing engine efficiency will reduce petroleum usage.

Reviewer 2:

The reviewer explained that this is certainly a revolutionary approach to exhaust heat recuperation to enhance combustion with fuel reforming in a partially deactivated engine at low brake mean effective pressure (BMEP).

Reviewer 3:

The reviewer stated that the project is broadly relevant to the goal of improving fuel economy. It is unclear, though, how the approach fits in with the 35% target. This reviewer also indicated that the idea of in-cylinder reforming is risky and unorthodox, hence the recommendation to bring on an engine manufacturer.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that experimental efforts for this engine research can use more funding.

Reviewer 2:

The reviewer agreed that the annual project costs of about $300,000 seem reasonable.

Reviewer 3:

The reviewer indicated that some reallocation to include more analysis to speed development and seeking industrial participation to ensure the technology has someplace to go in terms of application is highly recommended.

High-Efficiency Clean Combustion in Multi-Cylinder Light-Duty Engines: Scott Curran (Oak Ridge National Laboratory) - ace016

Presenter

Scott Curran, Oak Ridge National Laboratory.

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

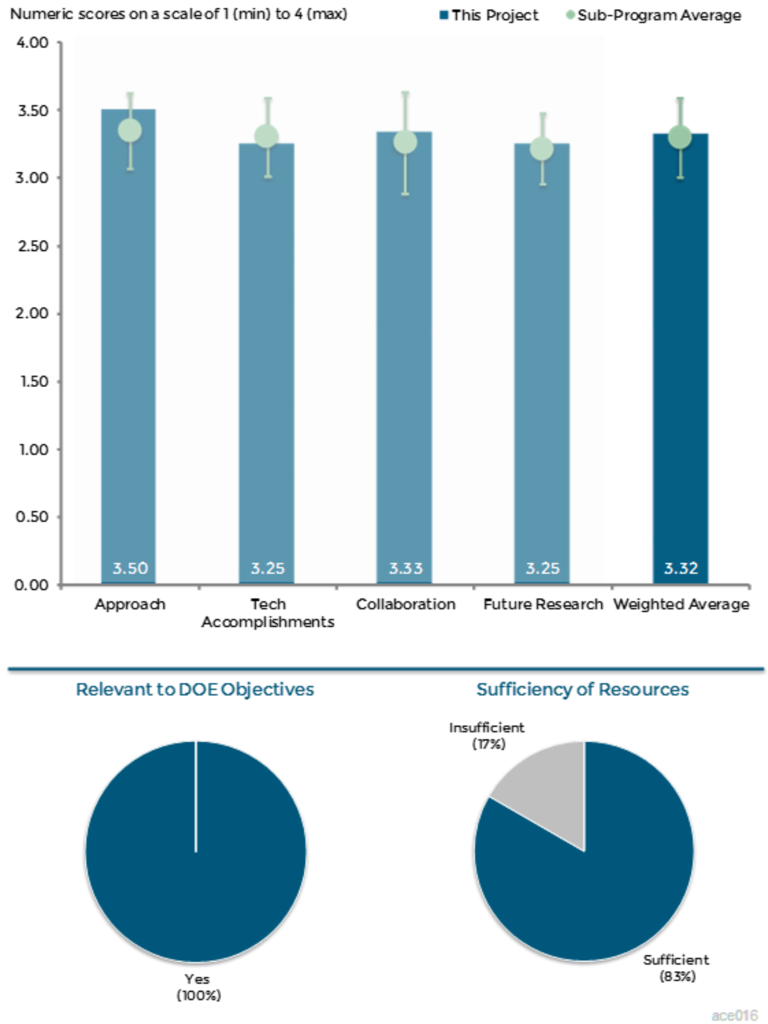

Figure 4-13 High-Efficiency Clean Combustion in Multi-Cylinder Light-Duty Engines: Scott Curran (Oak Ridge National Laboratory) – Advanced Combustion Engines

Reviewer 1:

The reviewer indicated that the systems level approach of evaluating advanced combustion technologies through testing on a multi-cylinder production engine platform with realistic auxiliary equipment coupled with drive cycle simulations is an excellent approach for assessing the real benefits and challenges of these technologies. The approach also helps to refine the results obtained from single cylinder studies.

Reviewer 2:

The reviewer commented that it was very nice to see a practical engineering evaluation of a reactivity controlled compression ignition (RCCI) powerplant in a vehicle. The approach has been outstanding throughout the years toward integrating research level activities in high efficient combustion strategies to multi-cylinder engines and then eventually into a LD vehicle.

Reviewer 3:

The reviewer stated that the approach is very good. A multi-cylinder systems level approach, with real air-handling systems, etc. is followed, which is needed to understand the real potential of LTC systems

Reviewer 4:

The reviewer observed that the project approach of looking at combustion through vehicle level efficiency is appropriate for evaluating the potential for LTC modes to replace diesel combustion. This reviewer expressed will be happy to see results using the new noise and vehicle fuel economy metrics as those will be much more indicative of how the engine might run in real-world use. As many of the reviewer questions hit on, the real key will be how to handle cold-start, warmup, and transient operation. It seems safe to assume that aftertreatment will always be required so consideration of the engine in light of that reality seems important.

Reviewer 5:

The reviewer expressed an agreement that the project is valuable in taking a concept such as RCCI towards its validation on a production platform. The project emphasizes the importance to work on the system integration and the respective challenges.

The project would benefit by including a technology review of previous RCCI that will frame the expectation of both load extensions, fuel consumption and emissions benefits.

Reviewer 6:

The reviewer said that application of RCCI/LTC, and addressing lack of emission data.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer reported that excellent progress in evaluating the RCCI technology, including: development of RCCI engine maps for using the drive cycle simulations; demonstration of capability to obtain an efficiency in an MCE that meets the 2020 ACEC stretch goal of 36%; and evaluation of the performance and emissions of UW's hybrid RCCI vehicle.

Reviewer 2:

The reviewer indicated that the technical accomplishments have been outstanding especially in assessing the possibility of using RCCI in powerplant. Though the results have been limited to predominately steady-state conditions the accomplishments have nevertheless been impressive. This reviewer also suggested that future work should further address key challenges with this type of engine system.

Reviewer 3:

The reviewer observed that good progress has been made. Work towards evaluating transient control capabilities of RCCI should be accelerated.

Reviewer 4:

The reviewer agreed that the work in the last year has moved things forward, with evaluations of the drive cycle potential (absent emissions), and other features of RCCI. This reviewer expressed a need to see more discussion of the likely fuel economy penalty between a laboratory demonstration and a production calibration level engine so that the comparisons to production baselines are more realistic.

Reviewer 5:

The reviewer commented that the project team completed engine maps covering RCCI over a wide portion of the map. Fuel efficiency improvements, which are applicable to a portion of the drive cycle, give estimates of the fuel economy gains within the targets of the program. This was applied to wide range of engines across two cycles. The project includes good instrumentation, especially in the PM sample and size distribution, via TSI and tandem differential mobility analyzer. The work provides a valuable insight to adapt RCCI to a hybrid powertrain. This was shown to be useful too in the EPA-led HCCI studies on medium duty (MD) engines on an UPS demonstration. This reviewer recommended that the project team provide heat release traces and an energy breakdown that are tied into the reported operating efficiencies. The figures of Slide 10 are informative but require more explanation. The reviewer explained that the engine has two fuel injectors, retaining the diesel DI unit. Results report UHC, CO, NO_x. No data is given of soot. This reviewer suggested that it may be valuable to understand the soot-NO_x tradeoff and what optimization has been done or is planned, as for example, the diesel injector nozzle hole geometry and pressure sensitivity as this fuel will be responsible for most of the soot emissions. The reviewer stated that engine out NO_x seems high and questions if it is likely that lean NO_x aftertreatment will be needed after all. The reviewer warned that engine-out HC is high and combined with low exhaust temperature that poses a problem. Extensive warm up with diesel only might erode into efficiency gains with LTC. This reviewer declared that it is commendable that the ACEC noise and efficiency recommendations are being followed.

Question 3: Collaboration and Coordination with other institutions.

Reviewer 1:

The reviewer confirmed that the PI has done a great job leveraging many resources throughout the years. Great job!

Reviewer 2:

The reviewer noted that the growing collaboration with LANL and SNL will be very good. The existing collaborations seem effective, though the reviewer would argue that ORNL has gone well past UW in terms of useful RCCI work.

Reviewer 3:

The reviewer indicated that a good level of collaboration with one auto manufacturer and two equipment and catalyst suppliers as well as several universities and the other national laboratories.

Reviewer 4:

The reviewer said that it is a good team. Very impressive to see how the project incorporated the UW at Madison hybrid vehicle and National Instruments controller.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer agreed that the plans going forward do appear well positioned to pick off the main trouble points for RCCI. This reviewer would encourage as much effort towards transient operation and dealing with the mode switching and emissions variation from that style of operation as being key. The series hybrid results were interesting, but not realistic for what vehicles will operate like.

Reviewer 2:

The reviewer stated that that planned work to look at multi-mode transitions and the needs of auxiliary equipment and aftertreatment will help to further evaluate the viability and needs of the RCCI technology.

Reviewer 3:

The reviewer pointed out that the team highlighted remaining challenges and barriers, including load extension, transients and controls, and aftertreatment.

Reviewer 4:

The reviewer indicated that the proposed work is very reasonable. The only suggestion is to include some focus on the warm strategy for the RCCI powerplant and also work hard to refine transient control on the MCE RCCI engine.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that the project directly supports DOE goals by evaluating one possible multi-cylinder high-efficiency low-emission engine system.

Reviewer 2:

The reviewer noted that the assessment and comparison of various advanced combustion technologies on the same MCE platform is very valuable for identifying the technology or technologies that have the most promise for improving engine efficiency and reducing emissions to best meet or exceed DOE goals.

Reviewer 3:

The reviewer reported that this project is well aligned with enabling production consideration of LTC.

Reviewer 4:

The reviewer explained that it is important to have a program where the initial concept of RCCI done mostly at the university level can be evaluated more thoroughly and the barriers and challenges be more clearly identified by a team such as the one consolidated at ORNL.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer brought to light that the downward trend in funding for this project is troubling. The work done here is perhaps the most focused on real-world issues with LTC and should receive funding in proportion to that.

Accelerating Predictive Simulation of Internal Combustion Engines with High Performance Computing: Kevin Edwards (Oak Ridge National Laboratory) - ace017

Presenter

Kevin Edwards, Oak Ridge National Laboratory.

Reviewer Sample Size

A total of seven reviewers evaluated this project.

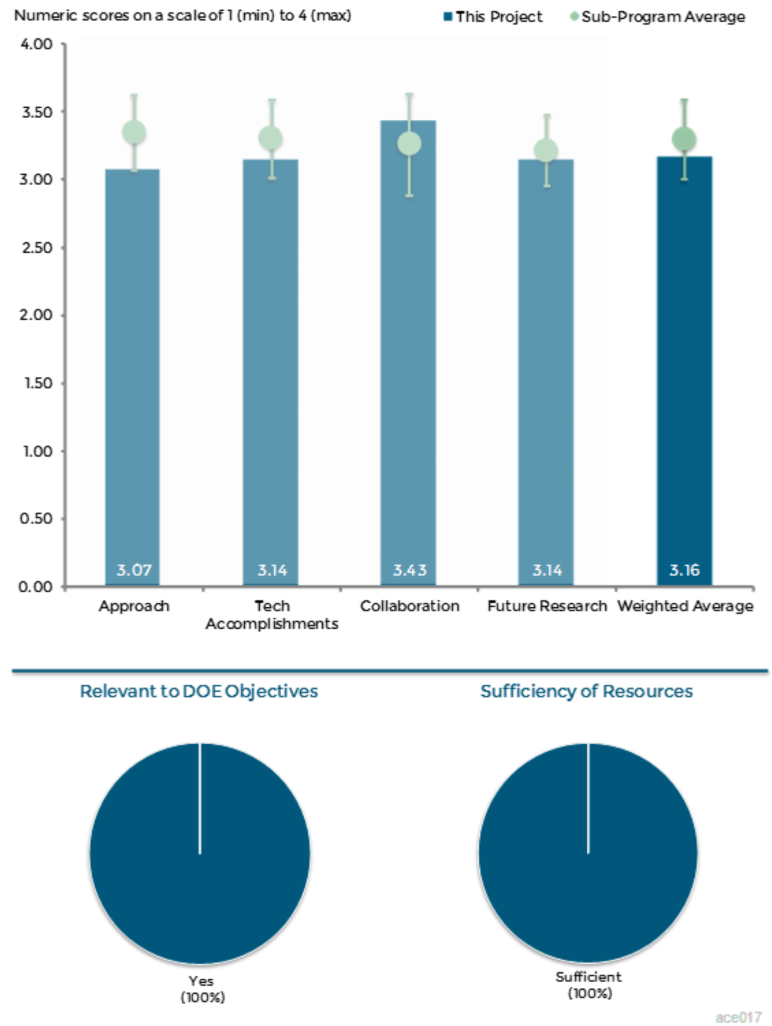

Figure 4-14 Accelerating Predictive Simulation of Internal Combustion Engines with High Performance Computing: Kevin Edwards (Oak Ridge National Laboratory) – Advanced Combustion Engines

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer indicated that there is no doubt that multidimensional engine analysis is key to understanding what's going on inside the cylinder of an IC engine (particularly when coupled with optical and conventional engine experiments). As more challenging efficiency and emissions requirements emerge, the need for more and better engine simulations grows, thus the requirement to accelerate the analysis process with high performance computing. The reviewer concluded this project does an exceptional job of marrying the facilities at the national laboratory level with the engine makers who can make the most use of these resources to advance engine technology.

Reviewer 2:

The reviewer explained that this project concerns developing a predictive capability for an ICE. The rationales that motivate the effort are common among projects that are simulation-based, for example facilitate design, reduce time-to-market, and reduce cost. The approach taken is to combine two codes, openfoam and converge, to validate, improve, and employ predictive injector flow models with the ultimate purpose to solve the unsolvable. This reviewer suggested that it would help the project if some discussion could be devoted to the limitations of existing simulation tools that motivate the one(s) employed here: some context would be useful. The reviewer commented that some codes are free with full access to the source code while others are not. As presented, there was little discussion of why Converge was chosen (for example) beyond that it is a good spray solver, that it can predict cavitation or flash boiling during the injection process, or that it is what the industrial collaborators want to use. The reviewer questions what about the use of KIVA (LANL), RAPTOR (SNL) and others. The PI brings unique expertise, computational capabilities and their extensive knowledge to the project and should advise the industrial collaborators rather than (if this is the case) just use what is wanted. It was suggested future presentations should list the virtues and limitations of competing computational tools. Nothing is perfect and the community would benefit from the PI's perspectives. The reviewer noted that the ultimate goal of a fully predictive simulation approach is to improve engine efficiency. However, it was difficult in this presentation to see the link of all the tools being developed to this end. For example, the reviewer expressed a need to understand if spray penetration can be accurately predicted, how this will be quantitatively related to fuel economy, if droplet collisions occur, and what the impact is of the physics on efficiency beyond qualitative connections.

Reviewer 3:

The reviewer stated that the project seeks to use high speed computing to improve the predictive capabilities of simulations. The simulation times reported are long and costly. The reviewer suggested that the authors need to show how to bridge the use of these massive computational tools to practical industrial applications, beyond the selective demonstration projects that are selected here (e.g. the General Electric [GE] locomotive project).

Reviewer 4:

The reviewer acknowledged that implementation of industry relevant CFD software to super computers is a great step. This reviewer questioned how this capability can be rolled out to additional industrial partners.

Reviewer 5:

The reviewer reported that HPC coupled with an industry partner helps to ensure relevance of project results.

Reviewer 6:

The reviewer affirmed that the approach to develop and improve the understanding of fuel injector behavior is important to improving combustion efficiency and bringing technologies to market with reduced development time and cost. This reviewer also noted that it is unclear the level of involvement from suppliers or OEMs in the definition of the approach. If the intention is to improve understanding of the fuel injection systems, the reviewer questioned if new nozzle geometries, nozzle hole manufacturing processes, coatings and other key relevant aspects of the fuel injector have been considered in a matrix to actually perform the optimization. This reviewer also asked if the goal of this study is only the development of the tool and not the use of the tool itself to effect change by component or system level optimization. The reviewer said that there is a goal mentioned to translate the capabilities from HPC to desktop on board diagnostic (OBD) and controls, but did not see a path to achieve this technical goal. It is unclear if an OEM could use this tool in a practical manner without HPC. The reviewer asked what the path is to removing the need for powerful computations for the aforementioned tasks. The reviewer indicated that the studies on cyclic variability are interesting and important for future combustion control regimes, but it is unclear if this is part of ace017 or ace090. The study on GPU acceleration of numeric solvers approach is in its infant stages. The reviewer commented that it is stated that in Fiscal Year 2017-2018 a demonstration of an accelerated, fully optimized injector design will be done, and asked if this project ace017 will continue for three more years to accomplish this goal. There is no communicated percent complete to date information or information about the future project timeline communicated in a clear manner. The reviewer explained that it is difficult to assess the approach for the remainder of the project or what is inside or outside the scope of ace017 because the presentation is inclusive of information pertaining to multiple projects at multiple phases. This reviewer expressed that one cannot asses with confidence what is really being done in ace017 and cannot therefore give a clear assessment of the approach.

Reviewer 7:

The reviewer expressed that one is not sure if HPC has a pathway to being used as a design tool by industry. It takes too long and it costs too much. It is certainly a long-term play.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer commented that progress on the various projects has been excellent. Of course, there are many more challenging problems out there (it is a target rich environment), so the team is encouraged to continue seeking out new partners and new problems to tackle. The Cooperative Research and Development Agreement (CRADA) bringing together ORNL, LLNL, Indiana University, and Cummins is a positive step in this direction - more joint work with other laboratories (ANL comes to mind) as well as more industrial and academic partners is encouraged.

Reviewer 2:

The reviewer indicated that the GM fuel injector simulation results are looking good. It seems like the model is able to predict flash boiling quite well. This reviewer expressed that one is not sure what kind of progress is being made on the Ford cycle-to-cycle variability. Perhaps the goal and progress on this project needs to be described better so the reviewer can understand it better. The reviewer noted an agreement that the GE Diesel Locomotive Natural Gas project is very relevant and interesting.

Reviewer 3:

The reviewer explained that simulations and developments to date seem to be progressing, with test data and simulation data being generated as planned. In order to accomplish the task of reducing time to market for technologies and improving fuel economy. It would be helpful to see how this tool is expected to reduce time to market or improve efficiency in reality. The start to finish injector design that is planned will be vital to understand the success of the program, and to see if it could be done faster and with less cost than traditional simulation and test methods. The reviewer stated that there is a goal mentioned to translate the capabilities form HPC to desktop to OBD and controls, but the reviewer did not see a path to achieve this technical goal. It is unclear if an OEM could use this tool in a practical manner without HPC. This reviewer also questioned what the path is to removing the need for powerful computations for the aforementioned tasks.

Reviewer 4:

The reviewer noted that the authors have selected a GDI fuel injector for design optimization. The present effort appears focused on approach and methodology. The work is coordinated with GM facilities. Work currently focuses on internal flow nozzle description and the impact of flash boiling on plume angle (modeling). Tests included a range of ambient temperatures highlighting the effects in the injection pattern. Work will then continue by incorporating models on Converge for engine modeling studies. This reviewer suggested that the overall direction of the project may be better appreciated if the authors provide a detailed list of issues or concerns and their prioritization. The reviewer mentioned that the project also looks at cycle-to-cycle variability including impact of stochastic input noise on the simulations. The authors highlight the high sensitivity of the noise in highly dilution cases. The reviewer also expressed that it is unclear how effective or practical the uncertainty quantification meta-model approach. The reviewer explained that the variability analysis was applied to a locomotive dual-fuel engine but there is little representative data. No discussion is given to possible mechanisms to limit variability; nor is variability depicted as a function of key parameters such as dilution, combustion timing, diesel-to-natural gas ratio, etc.. As noted earlier, it is unclear what value this brings. The reviewer observed the CRADA for GPU acceleration of numeric solvers appears to be beginning. This reviewer also stated that regarding the cyclic variability, the tool is being developed and first analysis indicates experimental data is matching simulation results in a sufficient manner.

Reviewer 5:

The reviewer suggested that regarding injector spray design optimization, a description of the optimization criteria for the injector design would help the audience understand the task and the trade-offs involved.

Reviewer 6:

The reviewer questioned if correlation between simulation and hardware for injector sprays be quantified. Visual spray comparisons appear to correlate but a quantifiable metric would be good.

Reviewer 7:

The reviewer explained that this was a difficult project to evaluate because the organization of the topics was not especially clear, making it more difficult to follow the progression of thought in several spots, and suggested that in presenting the technical accomplishments, it is recommended that the PI list, perhaps restricted to just one slide, the things done then pick one or two to discuss in greater detail. The model validation seems to involve comparing spray imaging with (apparently) predicted spray patterns (it was not very clear how the validation was carried out, though) using results from GM's visual interference imaging set up and cylinder pressure at various crank angles. This reviewer also stated that the confusion here is that it was thought that the reporting year did not consider combustion. The reviewer asked if the data in this validation were taken under combusting conditions. The spray images seem qualitative. The reviewer questioned precisely what data comes from them, what their uncertainties are, what is being predicted, and what is being measured. The reviewer asked if things like measured spray penetration or cone angle are being compared, is that enough to assess the efficacy of numerical tools. The reviewer also asked what about SMD and the distribution of velocities. These items would provide a more stringent test of the code's capabilities, even for the case of injection into a cold ambience. The reviewer suggested that more quantitative variables for validation should be used than simply what appear to be fuzzy images of sprays penetrating into a combustion zone, if that is what was done. The reviewer stated that if hexane is being injected into a 40 atm ambience, it would seem that dissolved gas effects could influence the results and asked if that is that correct. The reviewer questioned why the collision and coalescence model of converge turned off and why not turn it on. The reviewer observed that the PI notes that droplets were injected in the post-primary atomization process. This reviewer also suggested that more simulations on droplet trajectories and sizes would be useful, especially for cases where the droplets are in the process of evaporating. The reviewer noted that flash boiling was mentioned. It is not clear precisely what fuel was examined. Because vaporization under such conditions requires some degree of super-cooling, discussion of this point should be provided. The reviewer asked if the PI knows the conditions under which the fluid thermal state must vaporize in a flash boiling configuration and if not can the PI measure it.

Question 3: Collaboration and Coordination with other institutions.

Reviewer 1:

The reviewer indicated that there is a wide range of collaborators across national laboratories, academia and industry, which supports various projects within the program run at ORNL. Teams appear well integrated. Nevertheless, the collaboration effort needs to be demonstrated in establishing successful industrial demonstration projects.

Reviewer 2:

The reviewer remarked that the collaborative efforts with partners is impressive and broad. It would be beneficial to see more involvement from an injector suppler to help define a simulation and test matrix for injector optimization in a targeted combustion system to support the stated desire to perform design iterations for a real world optimization.

Reviewer 3:

The reviewer commented that there are many team members and a lot of tasks are being pursued. The collaborations seem reasonable, but the presentation was not especially clear (beyond mere statements) what certain entities were doing that contributed to the project. This reviewer also suggested that for a complex team greater thought should be given to how the pieces fit together. Perhaps a reduction in the scope of this project would help to bring greater focus to it.

Reviewer 4:

The reviewer reported that the partners in the projects to date seem well integrated and making good use of the resources that ORNL has to offer.

Reviewer 5:

The reviewer pointed out that it was good to see collaboration with CSI and LLNL to implement GPU-based Converge. This will eventually impact the speed with which industry can run simulations.

Reviewer 6:

The reviewer said that there is good collaboration with GM and Ford.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer acknowledged that the planned future work is vital to the success of the project. To not only develop the tool but to make it available for use with OpenFOAM, CONVERGE is very good. This reviewer explained that the goal to perform an injector design is very interesting if the simulation and test matrix is planned out in a manner such as design of experiments which is broad enough to truly optimize an injector, not just the testing of one injector to validate a model. The reviewer observed that the cyclic variability to comprehend and understand the key contributors to variability will be interesting.

Reviewer 2:

The reviewer explained that GPU technology may be a game changer, making large scale engine simulations cheaper and faster with the right software. Unfortunately, the traditional CFD software grew up on the CPU and some significant rethinking of how memory is used may be needed, but remarked that it will be interesting to see if the LLNL/ORNL/CSI team can make this jump. If possible, the results could make large scale simulations with detailed chemistry more than just an academic exercise and an even more powerful design tool.

Reviewer 3:

The reviewer pointed that out the future work is outlined briefly. This includes validation of injector model, apply meta-model approach to support experimental high-dilution control efforts at ORNL, identify and refine additional stochastic parameters and deterministic feedbacks for dual-fuel combustion, and implement GPU acceleration for flow and combustion solvers. This reviewer also suggested that the work appears to need a more visible tie-in to concrete milestones.

Reviewer 4:

The reviewer summarized that that the remainder of 2015 is to evaluate impact of LES turbulence on combustion stability. The reviewer commented this is nonspecific. In fact, this reviewer expressed the thought that combustion conditions were already part of the reporting year and that this issue (of turbulence) would be folded into the simulations that compare cylinder pressure with crank angle. It is a bit confusing. The reviewer said that real-world engines are noted and would like to know if the PI can be more specific. The reviewer suggested that more discussion of the flash vaporization process should be provided. This is a well-known process and it would be useful to know what is new about what the PIs' are doing in this area.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that a computational predictive capability of an ICE is, of course, important for improving engine efficiency.

Reviewer 2:
The reviewer mentioned that model predictability is an important element of combustion development.

Reviewer 3:
The reviewer reported that more efficient engines result from better designs. Multi-dimensional engine modeling can be shown to lead to better designs (ask the industry collaborators on this project). High performance computing facilitates better and faster simulations, better enabling, and more efficient designs that may not displace petroleum, but certainly reduce its consumption.

Reviewer 4:
The reviewer indicated that if combustion efficiency can be improved by finding an optimal combustions system, petroleum consumption could be reduced.

Reviewer 5:
The reviewer stated that the project supports the long term goal of HPC helping in the design of practical engines. However, it is not clear if industry is on a pathway to HPC currently.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer commented that the influx of CRADA money is hopefully the beginning of a trend to more industry support of this effort.

Reviewer 2:
The reviewer noted that this is a rather large team. Most of the computational effort seems to be at ORNL. It would help if the PI could give a breakdown of how the $400,000 was spent, because this category presumes the availability of such information (for example, resource sufficiency cannot easily be evaluated without knowing what the resources are used for)

Reviewer 3:
The reviewer commented that more clarity is needed in terms of the relative contributions of funding sources and the specific scope elements that they are fulfilling.

Joint Development and Coordination of Emissions Control Data and Models (CLEERS Analysis and Coordination): Stuart Daw (Oak Ridge National Laboratory) - ace022

Presenter

James Pihl, Oak Ridge National Laboratory.

Reviewer Sample Size

A total of four reviewers evaluated this project.

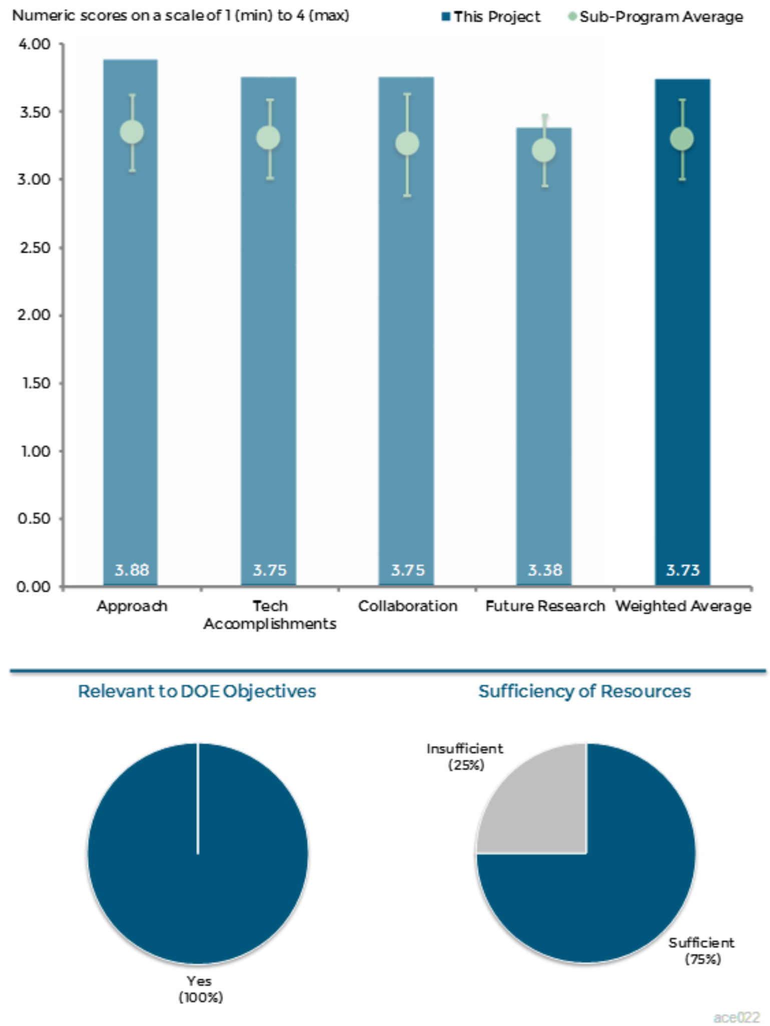

Figure 4-15 Joint Development and Coordination of Emissions Control Data and Models (CLEERS Analysis and Coordination): Stuart Daw (Oak Ridge National Laboratory) – Advanced Combustion Engines

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer indicated that this an outstanding effort. Cross-cut lean exhaust emission reduction simulation (CLEERS) has many moving parts and the approach continues to improve continuously year on year. Seeking input from industry customers is key and well-designed through workshops and regular meetings. This reviewer clearly observed topical R&D with selective catalytic reduction (SCR), diesel oxidation catalyst (DOC), PM, low-temperature catalysts, and other systems modeling on target list.

Reviewer 2:

The reviewer stated that the approach used in this work to understand the utilization of ammonia (NH_3) in an SCR is of great interest to the OEMs and lean aftertreatment community in general. The information obtained in this project has additional implications for OBD groups that are charged with developing routines to characterize the health of emerging aftertreatment technologies such as SCR catalysts.

Reviewer 3:

The reviewer noted that this approach of supporting models that are used for improved fuel economy and emission’s control is working very well. The CLEERS approach also leads to excellent communication within the practitioner community, communication that did not exist several years ago.

Reviewer 4:

The reviewer acknowledged that CLEERS workshops are always a great way for the emissions community to come together and share pre-competitive information. The monthly audios are also very effective for maintaining good communication and promoting collaboration within the emissions community.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer explained that the project plan, technical approach, and tools used in this work are very appropriate and provided a significant amount of useful information. Developing models to predict the NH_3 storage capacity of SCR catalysts and the storage sites is critical to understanding how to react NO_x under lean conditions and regenerate the catalyst with NH_3 for optimal NO_x reduction activity with minimum use of reductant species. This reviewer also commented that this type of research effort, which is also supported by CLEERS, is best provided by a national laboratory. The reviewer commented nice work.

Reviewer 2:

The reviewer indicated that the many goals for the CLEERS project were all completed. Being able to use component models in architecture studies for areas that were not intended to be used is impressive, for example, hybrids. The reviewer stated that NH_3 isotherm work in the presence of water is impressive and leads to a model that is very effective. Also, this reviewer said that there is good understanding of means of N_2O formation in lean NO_x traps (LNTs).

Reviewer 3:

The reviewer reported that CLEERS continues to stay focused well through workshops and teleconferences and has contributed to important advances in R&D for SCR, LNT regeneration, and SCR. To rate the project outstanding, CLEERS can support breakthrough R&D in passive SCR and LTC efforts.

Reviewer 4:

The reviewer remarked that the workshop and the audios are always very effective and well-run, and the efforts of those involved in organizing them are greatly appreciated, but suggested that DOE might consider extending the time for the talks to 25 minutes next year, in order to allow time for the presentation and also entertain questions. The reviewer indicated that good analysis was performed on the NH_3 storage capacity, especially the effects of H_2O and thermal aging, and particularly liked the investigation into the effects of the catalyst pretreatment on the NH_3 storage capacity. At this point, it looks like the 2-site model only allows another degree of freedom for matching the model with the data. The reviewer suggested that some investigation into the physical characteristics that determine whether a NH_3 storage site is a high energy site or a low energy site. The reviewer would like to see some other emission topics researched and modeled in addition to the NH_3 storage capacity of SCR catalysts and the N_2O formation from LNTs. One suggestion would be a greater emphasis on low temperature catalysis at stoichiometry.

Question 3: Collaboration and Coordination with other institutions.

Reviewer 1:

The reviewer commented that CLEERS provides many excellent opportunities for communication and collaboration between national laboratories, industrial partners, and educational institutions around the world.

Reviewer 2:

The reviewer stated that CLEERS in 2015 is well defined and per its mission serves well the auto industry OEMs/Tier 1 Suppliers as well as parallel research at universities and national laboratories.

Reviewer 3:

The reviewer indicated that collaboration and support for many activities is extremely broad, especially for CLEERS workshop and CLEERS conference calls.

Reviewer 4:

The reviewer noted that collaboration and support for many activities is extremely broad, especially for CLEERS workshops and conference calls.

Reviewer 5:

The reviewer suggested that inclusion of an OEM or wash-coat supplier as a reality check on the approach and work would have benefited this project. Feedback from OBD groups would also help both the researchers and the end users better understand the conditions and strategies the technology can be best utilized.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer emphasized that this is an excellent approach to future R&D targets and industry needs are well based on funding. This reviewer also pointed out that HC traps and other aftertreatment approaches for LTC are key needs for R&D.

Reviewer 2:

The reviewer agrees that future work to address remaining questions and fill the knowledge gaps is appropriate.

Reviewer 3:

The reviewer stated that the move to passive NO_x adsorbers is very welcome. This reviewer expressed a need to only encourage that CLEERS at ORNL keep track of the issues that come along with the effort in low-temperature catalysis and with low-temperature exhausts that are cool even after the engine has finished its cold start.

Reviewer 4:

The reviewer noted that there appears to be emphasis on HC traps in the future work, and work on NO_x traps is delayed until the middle of fiscal year 2017, but would like to see a concurrent investigation into HC traps and NO_x traps, as both will be important for achieving strict emission standards.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer explained that the improved communication and collaboration between national laboratories, car manufacturers, and universities that CLEERS promotes can and will contribute to the development of more efficient powertrains and aftertreatment systems that will lead to improved fuel economy and reduced emissions on vehicles and thus a reduction in the national petroleum usage.

Reviewer 2:

The reviewer indicated that the modeling capabilities resulting from the experimental-modeling synergies within the CLEERS project are directly useful in developing pathways to using less fuel in emissions control.

Reviewer 3:

The reviewer specified that effective aftertreatment for new combustion strategies is critical for productive use of new petroleum saving combustion schemes. This reviewer also commented that low-temperature combustion and improved approaches for lean NO_x management are examples of focus areas in aftertreatment that are clearly needed to implement demonstrated combustion fuel efficiency improvement strategies.

Reviewer 4:

The reviewer pointed out that this project supports U.S. Council for Automotive Research (USCAR)/U.S. Driving Research and Innovation for Vehicle Efficiency and Energy sustainability (U.S. DRIVE) initiatives to address the need for effective lean aftertreatment systems and technologies. This type of characterization and modeling is useful for OEMs in the development of their aftertreatment strategies.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer suggested that it is possible to increase the scope of the project with incremental budget. It was indicated current funds are well managed and productive. There should be consideration of increasing funding to improve water line on R&D focus.

Reviewer 2:

The reviewer thought that the resources could be expanded at ORNL to allow concurrent development of HC traps and NO_x traps.

Reviewer 3:

The reviewer acknowledged that this project is appropriately funded and staffed.

CLEERS: Aftertreatment Modeling and Analysis: Chuck Peden (Pacific Northwest National Laboratory) - ace023

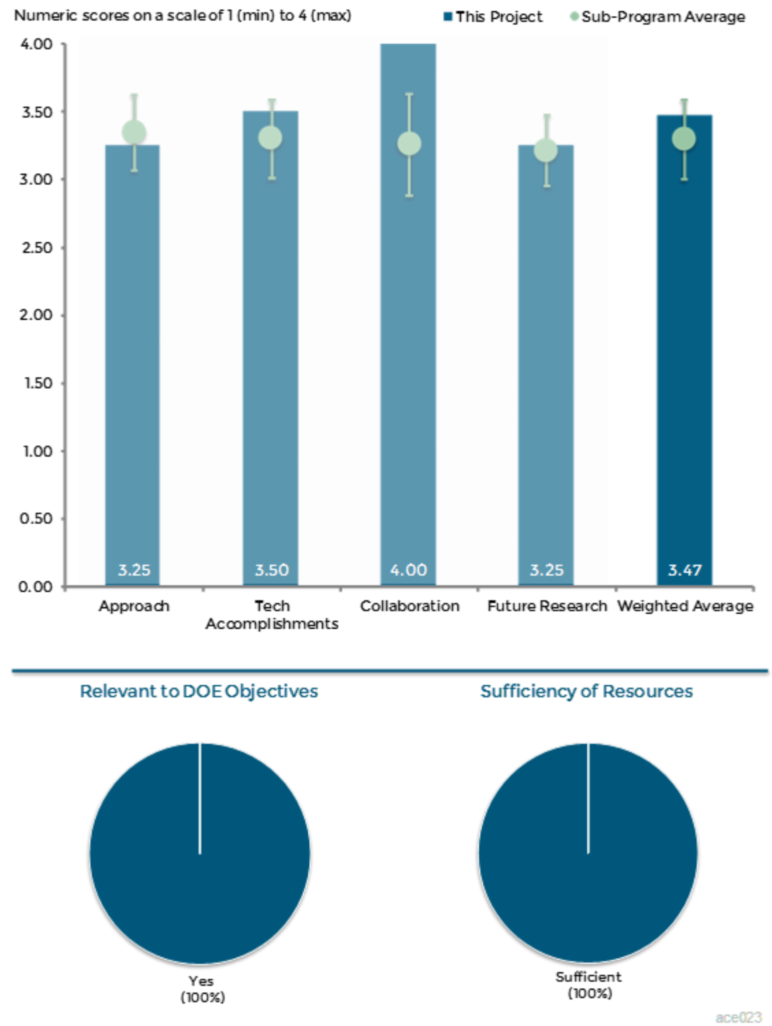

Figure 4-16 CLEERS: Aftertreatment Modeling and Analysis: Chuck Peden (Pacific Northwest National Laboratory) – Advanced Combustion Engines

Presenter

Yong Wang, Pacific Northwest National Laboratory.

Reviewer Sample Size

A total of two reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that the approach of having industry/others define needs, and then starting with fundamentals to satisfy these needs. These feed into CRADAs for beginning steps to practicality. Established and working. The reviewer concluded frequent communications to keep participants and industry informed and to solicit feedback.

Reviewer 2:

The reviewer expressed a warned concern about the overweighting focus on preparation methods for SCR as their relevance to modeling activities is not clear. It will be beneficial to measure and analyze the reaction kinetics and mechanistic pathways to show that the prepared model catalysts are relevant to practical applications. This reviewer also stated that it will also be helpful to understand better the aging and sulfur poisoning mechanism to facilitate aging model development.

The reviewer indicated that for passive NO_x adsorber (PNA), the focus should be on understanding the reaction mechanism and kinetics of NO_x storage/release, not on developing new catalyst formulations.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer pointed out that there was good quality work on SCR material preparation and characterization, and the mechanistic study on N_2O formation is of critical importance for SCR model development.

Reviewer 2:

The reviewer said that SCR and the explanation on N_2O preferential formation is very important. This reviewer also noted an expectation of a N_2O versus de-NO_x inverse relationship, and the need to quantify and inhibit. Synthesis accomplishments are important to provide model catalysts. This reviewer expressed a confusion on the significance for practical application although, it can provide a pathway to commercialization. However, the reviewer guessed that industry can develop their own methods. Finally, the reviewer the project is important for other researchers in their studies. The reviewer noted that very important and interesting results on the effect of iron (Fe) loading and Cu/structure relationships on SCR performance. Low-temperature aftertreatment protocol development is critically important. The reviewer questioned if others are beginning to use it. The reviewer stated X-ray/CT analyses of selective catalyst reduction on filters (SCRF) are interesting for assessing loading. This reviewer questioned to know what is next. The reviewer noted that the tool was developed and ready to apply. The reviewer was anxious to see application and impact on passive soot oxidation, diesel particulate filter (DPF) porosity impacts, and coating method, etc. The reviewer indicated that elements of the scope on GDI particulates seems to be similar to work at ANL with somewhat different results. The reviewer would like to understand the similarities in the these efforts and whether or not the corresponding results are consistent.

Question 3: Collaboration and Coordination with other institutions.

Reviewer 1:

The reviewer explained that the CLEERS program is designed for collaboration, so an excellent score is inevitable. However, visiting scientists are the best collaboration and these are excellent for strong mutual benefit and dissemination of knowledge. The reviewer suggested doing more of this.

Reviewer 2:

The reviewer noted that close collaboration with industry (Johnson Matthey (JM) and Cummins).

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer explained that that with nitric oxide (NO) to nitrogen dioxide (NO_2) dependencies, much of the difference between copper (Cu) and Fe may be due to the cation itself and not the location or structure, but suggested starting experiments with this hypothesis rather than to go through many reiterations on structure. Also, this is a very important property. Design the studies with new ion candidates in mind especially those that would not be sensitive to sulfur. The reviewer pointed out that durability work versus structure is important, but just as critical is sulfur tolerance. There is no work on poisoning for any new promising structures. The reviewer indicated that NO_x storage reduction (NSR) is becoming important for LD (as always) but also for California Air Resources Board (CARB) low-NO_x cold start regulations. Aging and sulfur tolerance become more critical in heavy duty (HD). The reviewer noted that on SCRF, the biggest issue emerging is impact on passive soot oxidation. This reviewer also explained that the project is gaining knowledge on zeolite structure, NO to NO_2 oxidation, and on x-ray CT and indicated the project is well-poised to expand earlier work on passive soot oxidation inhibition with SCRF.

Reviewer 2:

The reviewer suggested that the focus of this activity should be on generating knowledge on the reaction kinetics and mechanism to feed the modeling activities, not on developing new catalyst preparation methods.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This reviewer indicated that emissions regulations are tightening again and suggested low-FC strategies have unique problems and need emissions help.

Reviewer 2:

The reviewer said that SCR is a key enabling technology for diesel and lean burn gasoline engines.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer affirmed that the results are impressive given the resource allocation. Unless there are changes, the progress should continue.

Particulate Emissions Control by Advanced Filtration Systems for GDI Engines: Hee Je Seong (Argonne National Laboratory) - ace024

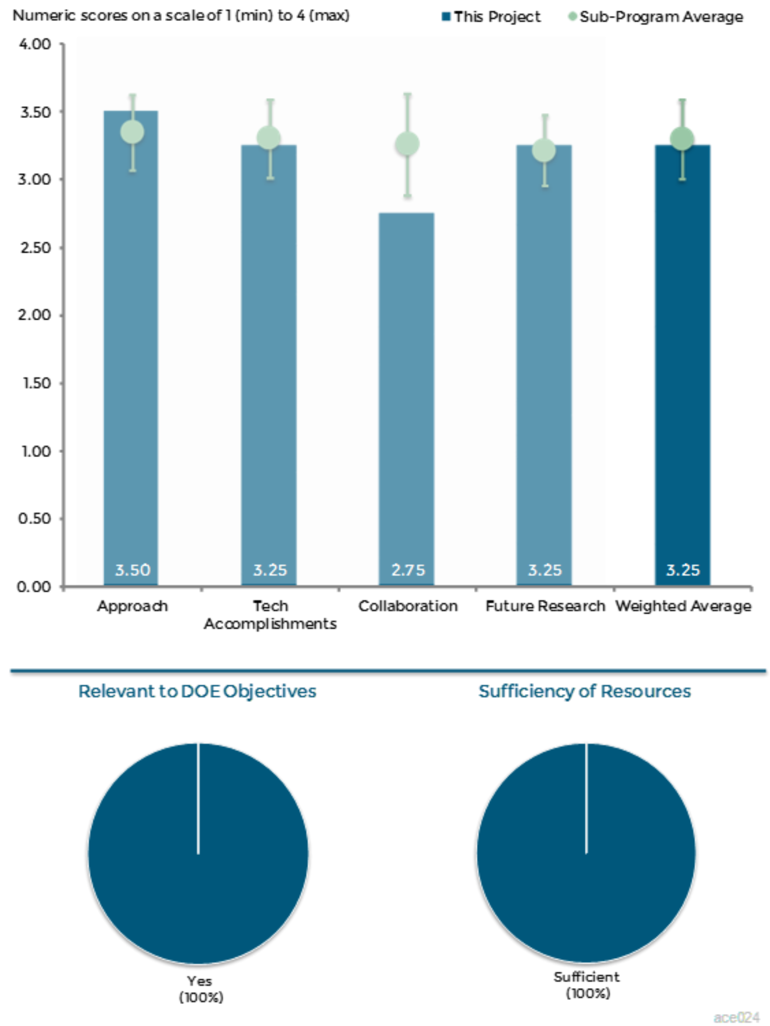

Figure 4-17 Particulate Emissions Control by Advanced Filtration Systems for GDI Engines: Hee Je Seong (Argonne National Laboratory) – Advanced Combustion Engines

Presenter

Hee Je Seong, Argonne National Laboratory.

Reviewer Sample Size

A total of two reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that careful characterization of ash effect on filter performance (back pressure, filtration efficiency etc.) addressed a key issue in gasoline particulate filters, especially related to three-way catalyst (TWC) wash-coated filters

Reviewer 2:

The reviewer explained that this project takes a good approach in characterizing the filtration system for GDI engines. Study and findings with ash loading on gasoline particulate filters (GPFs) of various configurations contribute to the knowledge base of the field. It provides guidance for future design and operation of GDI engine as a system, from filter design to additive considerations for fuel and lube oil. This reviewer also suggested that it would be beneficial if some theoretical work could be included in the future to explain the observations. For example, what is the underlying chemical/physical mechanism that calcium (Ca) presence would enhance soot oxidation?

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer commented that the promotional effect of Ca on soot regeneration is interesting. However, it is not clear how the presence of ash would improve soot oxidation with very low oxygen (O_2) availability. This reviewer also suggested that a further investigation to the mechanism seems reasonable.

Reviewer 2:

The reviewer affirmed that good progress has been made with regards to the effects of catalyst/ash loading, porosity of the filter as well as their interactions. Testing tools and methods are excellent, but indicated, however, some of the conclusions are too general from the data presented. For example, the conclusions with regards to ash loading were based on a comparison between no ash and 2 gram per liter (g/L) only. The reviewer questioned if the conclusions would still be valid if the ash loading is 10g/L.

Question 3: Collaboration and Coordination with other institutions.

Reviewer 1:

The reviewer indicated that collaboration and coordination with Corning, Hyundai, and universities have been good. However, the expertise of the team is limited to filter material, testing and soot measurement and characterization. This reviewer also suggested that in the future, some organization with expertise in the chemical kinetics in catalysis should be included to help to explain the observations.

Reviewer 2:

The reviewer noted that although the industrial partners provided test articles (engine and filters), the project could benefit from more regular technical interactions among the partners.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer noted that it is critically important to gain knowledge on catalyst wash-coat, soot, and ash distribution profiles in high porosity filters, especially for the field aged filters.

Reviewer 2:

The reviewer stated that proposed future work is reasonable. Again, to understand the mechanisms of enhanced soot oxidation the team needs to include a technical expert in this area.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer pointed out that this project addresses PM emission control from a GDI gasoline stoichiometric engine, which offers fuel savings compared to port fuel injection (PFI) engines

Reviewer 2:

The reviewer explained that the findings from this study could help GDI engines in meeting future emissions standard. GDI engines improve fuel economy, which would support DOE objectives of petroleum displacement.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented that funding seems to be adequate for the remaining tasks.

Enhanced High- and Low-Temperature Performance of NO_x Reduction Materials: Feng Gao (Pacific Northwest National Laboratory) - ace026

Presenter

Feng Gao, Pacific Northwest National Laboratory.

Reviewer Sample Size

A total of three reviewers evaluated this project.

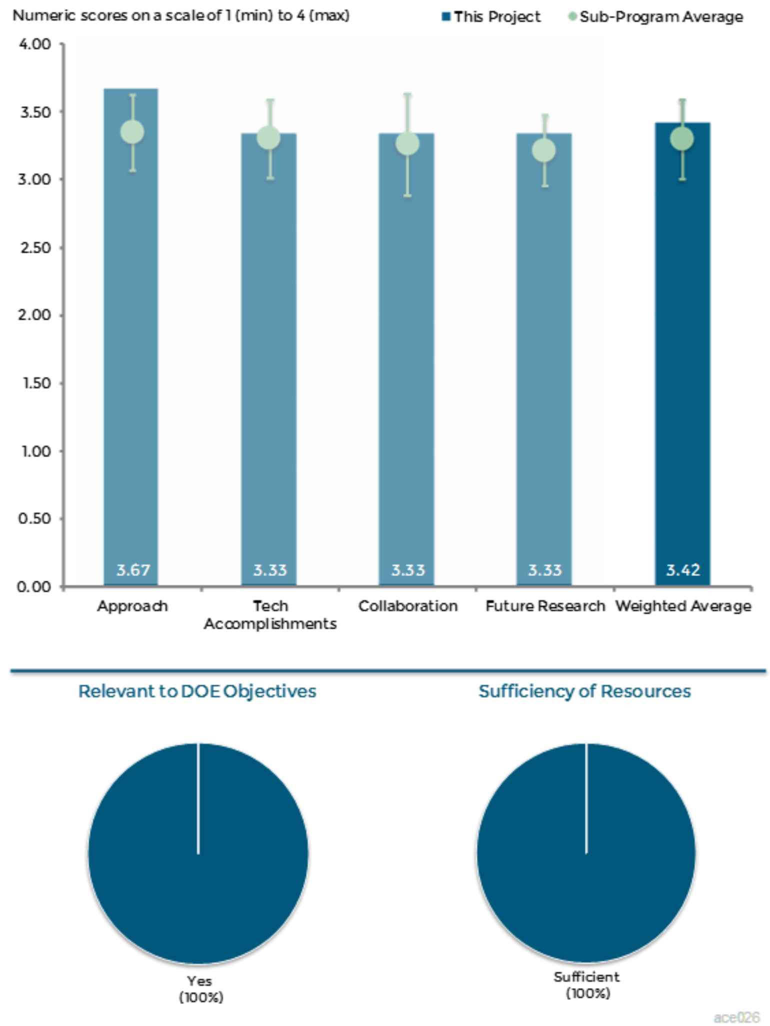

Figure 4-18 Enhanced High- and Low-Temperature Performance of NO_x Reduction Materials: Feng Gao (Pacific Northwest National Laboratory) – Advanced Combustion Engines

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer reported that this project takes an excellent approach in addressing the challenges in low-temperature NO_x emissions control. The work performed has been well designed and is of high quality with a clear focus on critical barriers facing the technology.

Reviewer 2:

This reviewer remarked that the approach seems reasonable. Pacific Northwest National Laboratory (PNNL) synthesizes catalysts based on iterative experiments. JM and Cummins provide baseline catalysts and results. The reviewer stated that it is not clear what role JM catalysts play in the scheme. However, these companies are catalyst experts and could be valuable in the collaboration. The reviewer likes the idea of using several zeolite families, analyzing structures and performance, and then tweaking the key parameters to determine effects on performance, and agreed with the shift away from NSR catalysts and fully into SCR.

Reviewer 3:

The reviewer pointed out that further expanding the operating temperature window is an important area for improving SCR catalyst performance, especially after realistic aging.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer noted that new results on Cu loading and Cu/SAPO-34 catalyst are valuable. In addition, optimum Cu loading was determined and explained. There was interesting work reported on Cu/SSZ-13 and cation interactions gives improved performance verses commercial catalyst, with explanation. This reviewer then stated that reducing NH_4NO_3 is important for N_2O reduction and low temperature (LT) performance. Work on mixed Cu and Fe chabazite (CHA) extends previous work and reduces N_2O. The reviewer said it is not clear that LT performance has been improved, which is one of the project's key deliverables. In addition, there are no results on structure/LT performance.

Reviewer 2:

The reviewer agreed that excess Cu loading causing SAPO-34 structure collapse is an important finding and a detailed study is warranted to further understand its mechanism. It is also interesting to see that reaction rates increases in the presence of coactions and the origin of this promotional effect needs to be addressed.

Reviewer 3:

The reviewer commented that good progress has been made in all focus areas. The findings have been very insightful. This reviewer stated that the identification of better SCR catalyst materials than the first generation of Cu/SSZ-13 is a major accomplishment. Synergy between Cu/CHA and Fe/CHA in limiting the N_2O formation is very interesting.

Question 3: Collaboration and Coordination with other institutions.

Reviewer 1:

The reviewer reported that collaboration and coordination with Cummins and JM was reported and seems to be good.

Reviewer 2:

The reviewer warned that the collaboration seems to be minimal and it appears the project team is not using JM and maybe even Cummins to their full potential. JM has some excellent catalyst understanding and should be more involved than simply providing baseline catalysts. Cummins is providing valuable testing capability and assume feedback into performance deficiencies and strengths. However, the reviewer stated that in the end, the main advantage of having JM and Cummins on the team is to transfer the technology into practice. This is and will be very important.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer observed that the proposed future work follows a well-planned path and is consistent with overall goal of the project. Leveraging with other NSF-DOE funded projects in understanding of catalyst mechanisms and limitations on theoretical bases is a good use of resources.

Reviewer 2:

The reviewer agreed that more work on durability and poisoning on the best candidates, as proposed, is a critical next step. This reviewer then stated that the project has built up significant understanding on processing, structure, and performance effects. The reviewer is not convinced that the project has the best zeolites, yet. This reviewer suggested that there should be leveraging work at Purdue University, University of Notre Dame and the University of Washington where more catalyst formulation work is occurring and incorporates their learnings into further optimization. However, again, in the end the project has made significant progress on understanding the strengths and weaknesses of zeolites and improving performance accordingly. It is difficult to say where the project is on the performance improvement evolution. The reviewer suspected that the project has already achieved perhaps 80-90% of the way to full optimization. Squeaking out that last 15% of optimum performance might be diminishing returns at this stage and perhaps a useful follow-up project after the other laboratories do their work. The reviewer warned that the project has not delivered better LT performance, yet future plans are ignoring this. Maybe further optimization based on improved understanding can be applied here.

Reviewer 3:

The reviewer stated that the work plan seems reasonable. The effect of zeolite acidity on catalyst performance at low and high temperature ranges is an important issue to better understand the surface chemistry and reaction mechanism. This reviewer confirmed that the effect of sulfur and hydrocarbon poisoning is also critical.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer remarked that this project addresses a key enabling issue with regards to LTC engine technology. Low-temperature engines improve fuel economy, which would support DOE objectives of petroleum displacement.

Reviewer 2:

The reviewer commented that $DeNO_x$ means de-carbon dioxide (CO_2) and "de-fuel-consumption" for most HD diesel and lean-natural gas calibrations.

Reviewer 3:

The reviewer affirmed that further improving SCR catalyst efficiency is critical to enable diesel engines to meet future stringent emission regulations.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer indicated that $300,000 is a bargain for the progress obtained. Given this performance and the resources of the partners for doing further durability and poisoning tests, no further public moneys appear not to be needed.

Reviewer 2:

The reviewer confirmed that funding seems to be adequate for the remaining tasks.

Thermally Stable Ultra Low-Temperature Oxidation Catalysts: Abhijeet Karkamkar (Pacific Northwest National Laboratory) - ace027

Presenter

Abhijeet Karkamkar, Pacific Northwest National Laboratory.

Reviewer Sample Size

A total of five reviewers evaluated this project.

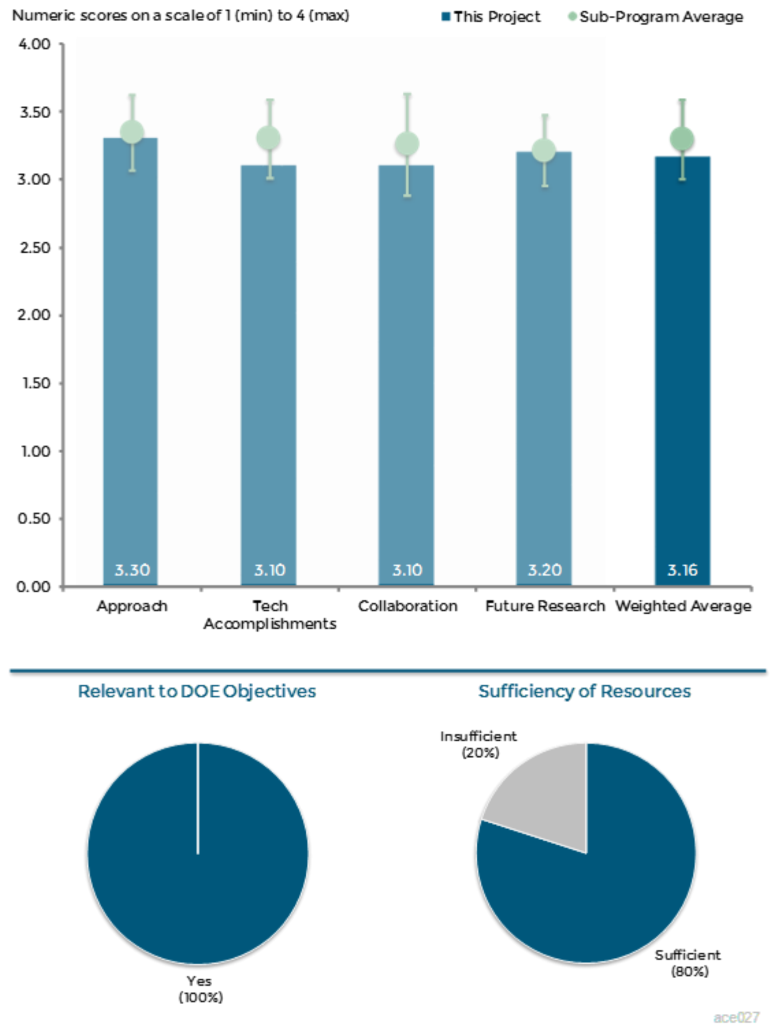

Figure 4-19 Thermally Stable Ultra Low-Temperature Oxidation Catalysts: Abhijeet Karkamkar (Pacific Northwest National Laboratory) – Advanced Combustion Engines

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer remarked that this is an excellent approach with requirements of the 150° Centigrade (C), challenging work directly identified from voice of the R&D customer through U.S. DRIVE workshop, with strong recommended technical scoping and requirements from three OEMs, two national laboratories, and DOE VTO. Resulting targets are succinct and relevant; temperature for 50% conversion of CO and hydrocarbon oxidation at 150ºC plus stable performance after 750ºC for 72 hours under 10% H_2O/air representing approximately 120,000 miles. This reviewer commented that excellent focus on non-platinum group metal (PGM) observed; this activity supports an important function of establishing specifications and targets for urea alternatives. Higher density NH_3 storage materials will be needed to obtain the level of NO_x control required for both HD and LD applications without sacrificing the vehicle owner experience. This reviewer also pointed out that currently, there are possible alternatives to urea that must be evaluated from an OEM point of view to determine their viability for use.

Reviewer 2:

The reviewer indicated that it is worth noting that this fairly new project has a different name and topic than that listed in the main agenda, because it now relates to solid NH_3 storage materials and not ultra-low temperature oxidation catalysts. However, the topic that USCAR and PNNL are interested in is a good one. The reviewer explained that the approach of looking at materials is fine, but other factors, including system issues in heating and using the NH_3 from different materials should also be addressed. In particular, choosing an optimum temperature range (less than100 degrees) over which the material begins and finishes releasing NH_3 is the main interest. Materials with high temperature release of NH_3 will cost too much in energy to be useful.

Reviewer 3:

The reviewer remarked that the project is a relatively broad investigation into various solid materials for NH_3 storage, but suggested that the project needs to consider non-chlorine materials that will not produce hydrogen chloride (HCl), as that can potentially cause problems with the catalysts and/or the paint around the exhaust pipe. It was necessary to go away from chloride salts of precious metals years ago because the HCl was causing pitting in the paint around the exhaust pipe.

The reviewer expressed a liking to the idea of a high-density solid source of NH_3, as that would overcome concerns about freezing of the urea solution. This reviewer then questioned how the project team would prevent H_2O from affecting the solid storage material. Even if the NH3 generation is performed in a separate chamber, there has to be a way to inject the NH_3 into the exhaust system. That would provide access for the H_2O from the exhaust to get into the NH_3 storage material. The reviewer asked if the rate of decomposition of the solid material sufficiently fast to provide enough NH_3 on the fly, particularly during periods of high flow rates and high NO_x generation, and then asked if the gaseous NH_3 that is derived from the solid source would have to be stored in a chamber so there would be enough available when it is needed; are there safety concerns about storing gaseous NH_3 on the vehicle; and how much volume would be needed. The reviewer stated that could be a concern on small vehicles (such as in Europe), where packaging constraints are always a concern.

Reviewer 4:

The reviewer suggested that having some conceptual idea of what might be effective might be helpful before preparing and testing samples.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer expressed a pleasure that the project team has identified quite a number of possible candidates. The team seems to be following a tree approach. This reviewer also indicated that doing binary mixtures is good and perhaps ternary will be on this list at some point. The reviewer commented to trudge on.

Reviewer 2:

The reviewer commented that although relative targets and goals were mentioned, well defined targets and goals were lacking in this work currently. These will be necessary to effectively rank the materials for providing NH_3 under the appropriate conditions. Also, realistic assessments of the urea alternatives must be more thought out. For example, downgrading carbamate as a urea replacement, because it yields CO_2 as a decomposition product, is not appropriate. Stating that the CO_2 from the decomposition will recombine in the exhaust at low temperature to reform carbamate is not unique to this material. In fact, any reductant that forms NH_3 in the exhaust has the potential to combine with the readily available CO_2 to form carbamate anyway. Also, the additional CO_2, from the decomposition of carbamate, is a negligible impact on the rated fuel economy. A more important aspect is its decomposition temperature and the density of NH_3 it can support.

Reviewer 3:

The reviewer reported that the results were quite broad over a large material base. It could be used as a means of down selecting materials.

Reviewer 4:

The reviewer observed strong near-term results pointing to possible formulations of low-temperature Cu/ceria-zirconia catalysts for 150°C CO and hydrocarbon oxidation and long term hydro-thermal aging robustness theorized to be due to identified praseodymium (Pr) and lanthanum (La) additives for enhanced structural stability.

Reviewer 5:

The reviewer mentioned that this is a nice study of the decomposition rate of various NH_3 storage materials. Again, need to emphasize non-chlorine materials to avoid the potential for HCl generation.

Question 3: Collaboration and Coordination with other institutions.

Reviewer 1:

The reviewer observed that there is a very good OEM, national laboratory team with well-defined roles.

Reviewer 2:

The reviewer pointed out that all three OEMs participated in this study, which is essential for writing specifications that will affect their products. However, the inclusion of an industry chemistry thoroughly knowledgeable of reactions involving these NH_3 compounds would provide useful feedback on the metrics used in this work. This reviewer also suggested frequent group meetings to discuss the project progress keep this project focused.

Reviewer 3:

The reviewer reported that good collaboration, but consideration of even broader cooperation would be good at this early stage.

Reviewer 4:

The reviewer observed that there was not a lot of collaboration with other institutions other than USCAR. It was mentioned that an OEM partner was being sought and asked what about partnering with a supplier.

Reviewer 5:

The reviewer expressed a consideration that conference calls every two or three months to be very low collaboration, and suggested it is an industrial's dream, for there is not much work and very few meetings.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer said that excellent follow on to interesting results to include zircon. This reviewer then concluded that future characterization studies of Cu/ceria-zirconia materials are an excellent enhancement to Cu/ceria effort with potential for improved durability performance.

Reviewer 2:

The reviewer agreed that it is a good choice of material studies, but need to develop clearer criteria for down selection choices.

Reviewer 3:

The reviewer mentioned that the double salts and eutectics could prove interesting. This reviewer highlighted that there is a need to consider materials that will not produce HCl. In addition, there is a need to consider how to prevent H_2O from the exhaust to adversely affect the solid materials.

Reviewer 4:

The reviewer observed that more appropriate targets and goals should be developed as refinement to this work progresses.

Reviewer 5:

The reviewer brought to light that there seems to be little effort to bring a systematic or conceptual approach to this project. The future work follows that mold, but questioned when and if the project team finds an acceptable alternative, will the team know why and will that led the project team to even better choices.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer declared that a solid NH_3 source for an SCR catalyst could increase the use of lean engines for improved fuel economy, particularly in cold climates where there is concern over freezing of the aqueous urea solution. As a result, heat must be used to heat the urea solution, which takes away from the fuel economy.

Reviewer 2:

The reviewer explained that identifying effective materials, understanding and defining mechanisms/limitations for low-temperature performance are critical to designing productive LTC to support new combustion strategies with significant efficiency improvement potential.

Reviewer 3:

The reviewer acknowledged that a good solution would allow greater penetration into the LD market where diesel powertrains would bring greater CO_2 savings.

Reviewer 4:

The reviewer concluded that high density NH_3 storage materials and systems are needed to enhance the use of lean aftertreatment systems that are increasingly becoming a part of OEM fleets' to achieve fuel economy requirements. Extending the vehicle range between refilling the reductant is important from a packaging point of view and owner experience.

Reviewer 5:

The reviewer mentioned that materials allow for less energy use at cold start.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer remarked that there is no evidence that the funding is insufficient for the experimental work. This reviewer also expressed a need for a conceptual component and that will probably require additional resources.

Reviewer 2:

The reviewer acknowledged that resources are appropriate, no additional personnel or funding required.

Cummins/ORNL-FEERC CRADA: NO_x Control and Measurement Technology for Heavy-Duty Diesel Engines: Bill Partridge (Oak Ridge National Laboratory) - ace032

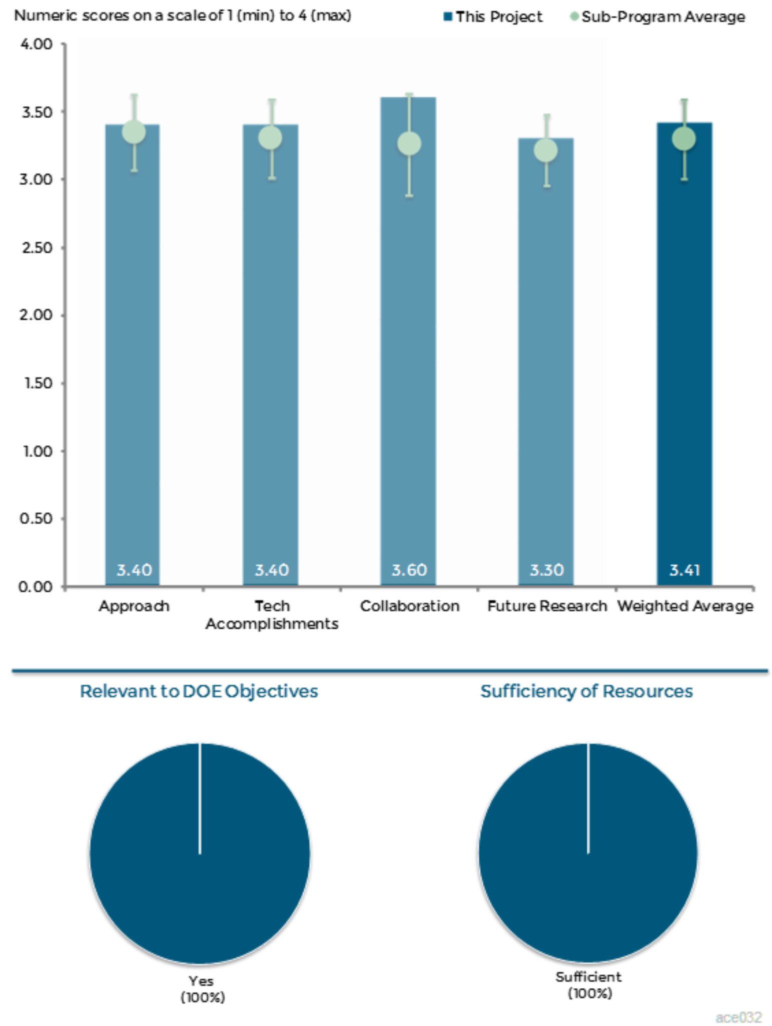

Figure 4-20 Cummins/ORNL-FEERC CRADA: NO_x Control and Measurement Technology for Heavy-Duty Diesel Engines: Bill Partridge (Oak Ridge National Laboratory) – Advanced Combustion Engines

Presenter

Bill Partridge, Oak Ridge National Laboratory.

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer reported that the project has an excellent approach to improve understanding of mainstream catalysts, catalyst aging with large contingency from industry CRADA.

Reviewer 2:

The reviewer agreed that the project has a good approach with a wide range of methods, especially spatially resolved capillary inlet Spaci-based.

Reviewer 3:

The reviewer remarked that it is an interesting approach of using Spaci to study the effects of field aging on the NH_3 storage capacity and NO_x conversion down the length of the sample. There needs to be a study on the effects of field aging on the front, middle, and back of the entire catalyst length (for example, not just the front of the front brick) and also from the middle and non-middle sections of the bricks (for example, the middle can be aged more than the non-middle of the bricks due to non-uniformity of the flow through the catalyst, especially at high loads and high flow rates). This reviewer observed that there is a need for a better definition of the field aging, like the number of miles (or hours) and the temperature histogram during the aging. The reviewer questioned if the catalyst was exposed to 1,000 miles of low temperature driving or 100,000 miles of high temperature driving. This reviewer also mentioned that there is a clue as to the severity of the aging.

Reviewer 4:

The reviewer reported that this project is always hard to review, and always goes back to see where the team said they would go, and wonders how the team got here. However, the result is always great even though the path is sometimes unclear, and, consequently, would never fault the approach.

Reviewer 5:

The reviewer pointed out that Spaci-MS tools are important for understanding the reactions occurring along reaction pathway and how NH_3 adsorbs and where it adsorbs. The approach provides helpful information of how much catalyst volume is needed as well as the effect of different species on the reactions themselves. This reviewer cautioned that this has been done by others as well, and questioned if the project team is reproducing this work. Aging effects also included in this work and its effect on reaction and storage.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer affirmed that the project has excellent studies of NH_3-SCR reaction and its field aged performance in its range of topics.

Reviewer 2:

This reviewer mentioned that the project has solid technical accomplishments to target for field aging and modeling study.

Reviewer 3:

The reviewer remarked that there was a very interesting breakdown of the total NH_3 capacity, dynamic NH_3 capacity, and unused NH_3 capacity. The project clearly points out that field aging is more severe on the NH_3 storage capacity than hydrothermal aging. This reviewer also questioned if there are plans to modify the hydrothermal aging procedure to better match the field aging. This might prove difficult, as the field aging is going to age the catalyst non-homogeneously (for example, ages the front more than the back and the middle more than the non-middle), which hydrothermal aging will age the entire volume uniformly.

Reviewer 4:

The reviewer commented that as always very helpful. The reviewer confirmed that the clarity on NH_3 storage in SCR catalysts will be very helpful in the modeling.

Reviewer 5:

The reviewer highlighted that understanding the effects of field aging (FA) on how a SCR function is lost is critical to developing SCR-based NO_x control systems. Including transient behavior in the study is also important for emulating vehicle operation and that effect on SCR activity. This reviewer brought to light that the work by others like GM and ORNL have shown the aging effects, so some of the work is completed by others already.

Question 3: Collaboration and Coordination with other institutions.

Reviewer 1:

The reviewer applauded the excellent collaboration, with multiple OEMs and universities supporting the work.

Reviewer 2:

The reviewer observed that the combination of Chalmers, Milano and Cummins is a who’s who of SCR investigations.

Reviewer 3:

The reviewer acknowledged that the range and quality of collaborators in this project is one of its main strengths.

Reviewer 4:

The reviewer expressed an agreement that Cummins is a very appropriate partner for this project for HD applications and suggested for LD applications, inclusion of an automotive OEM would be an additional benefit.

Reviewer 5:

The reviewer suggested that some comments on Cummins' contributions would be helpful other than supplying the field-aged catalyst.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer praised that the good choice of topics to take the project forward.

Reviewer 2:

The reviewer mentioned that it is solid proposed work to meet a very good plan. Part of current objectives that could be enhanced in future work is to identify strategies for catalyst-state assessment. This is very critical work for dynamic NH_3 storage and also related to aging. This reviewer concluded that the specific approaches and models to assist application engineering for catalyst formulations could be outstanding future work.

Reviewer 3:

The reviewer expressed a hope to see this project continued.

Reviewer 4:

The reviewer concluded that this work appears to be incremental rather than innovative, which is expected from a national laboratory. This reviewer also questioned if this work can be performed by industry.

Reviewer 5:

If the work is extended, the reviewer suggested that the statement of work should include a better characterization of the effect of aging along the axis and across the radius of the catalyst.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer confirmed that SCR is the technology for NO_x control in diesel engines and may become common in lean gasoline NO_x control. It allows those engines high fuel economy while meeting engine standards.

Reviewer 2:

The reviewer said that yes, SCR NO_x control systems are the leading technologies for meeting future emissions standards for lean diesel vehicles.

Reviewer 3:

The reviewer observed that aftertreatment strategies, modeling, and durability to enable the use of advanced combustion strategies to achieve nominally between 6-15% improvements in fuel consumption.

Reviewer 4:

The reviewer pointed out that a better understanding of the effects of field aging is needed to design systems that can improve the fuel economy (and thereby lower petroleum usage) while meeting strict emission standards with cost-effective aftertreatment systems.

Reviewer 5:

The reviewer concluded that improved performance even after field aging will be benefit.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer specified that equivalent or even more resources should be expended in the next phase of the project.

Reviewer 2:

The reviewer reported that the resources, both funding and personnel, are appropriate for the scope of this project.

Reviewer 3:

The reviewer agreed that resources for current targets are sufficient at level of good to excellent. Outstanding results for modeling and strategies for catalyst state assessment likely will require additional funding.

Emissions Control for Lean Gasoline Engines: Jim Parks (Oak Ridge National Laboratory) - ace033

Presenter

Jim Parks, Oak Ridge National Laboratory.

Reviewer Sample Size

A total of five reviewers evaluated this project.

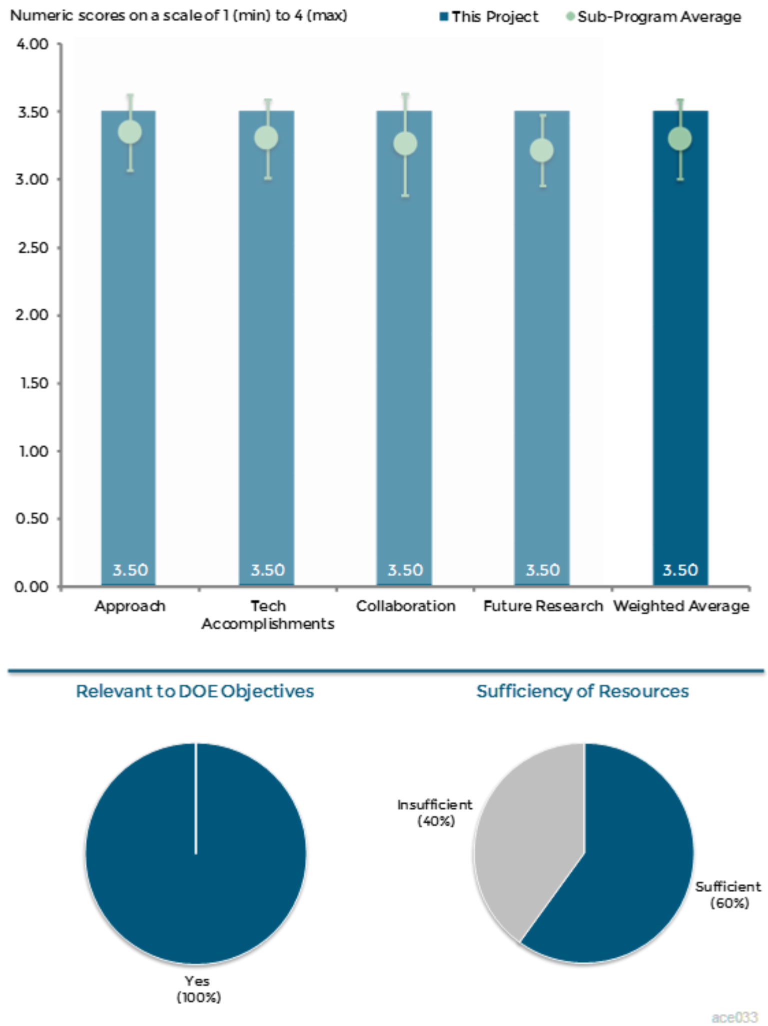

Figure 4-21 Emissions Control for Lean Gasoline Engines: Jim Parks (Oak Ridge National Laboratory) – Advanced Combustion Engines

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer remarked that this project is excellently conceived and designed to reach answers to the questions it asked about lean gasoline emissions control. The choice of conditions and catalysts was well done.

Reviewer 2:

The reviewer emphasize that d an excellent approach continues to evolve as emissions standards tighten up and feedback is presented. Precisely defined metrics include targets for fuel economy improvements over stoichiometric operation for each funding year as well as platinum group metal (PGM) count reductions. The reviewer specified that feedback from OEMs on value of passive systems, lessons learned and technical challenges would improve rating to outstanding. Several OEMs indicate passive system challenges are constraining use especially predictability of efficiently producing NH_3. The reviewer suggested sensitivity analysis in system modeling.

Reviewer 3:

The reviewer observed that this project benefits greatly from combining bench reactor results with appropriate engine testing. This is an excellent way to quickly determine the benefits of emerging technologies, under realistic conditions, and to assign cause and effect seen with vehicle testing. This reviewer concluded that this method of R&D has high value.

Reviewer 4:

The reviewer observed that there is a good combination of reactor testing and vehicle testing. It is also good to look at thermal aging and sulfur poisoning effects on the system. This reviewer also warned that the decrease in NH_3 production from the TWC with sulfur poisoning is a concern. One would need to de-sulfate the TWC periodically, and this will generate additional HC and CO emissions that must be integrated into the Federal test Procedure (FTP) emissions, requiring even lower emissions during the FTP. The reviewer suggested there is a need to consider PM emissions, especially for stratified charge. This might require a GPF, which would increase the back-pressure and therefore degrade the fuel economy. The reviewer noted that the rich times on the reactor are long. Need to be on the order of 5 to 10 seconds on the FTP.

Reviewer 5:

This reviewer mentioned that nitrous oxide (N_2O) formation over the TWC was commented on by a prior reviewer; however, no results are reported. The N_2O is produced usually when the gas composition over the oxidation catalyst (especially high Pt) is rich, or when the temperature is high 500-600° in the SCR catalyst (Bartley & Sharp SAE 2012-01-1082). The reviewer concluded because the N_2O limit is penalized over a value of 10 mg/mile, the aftertreatment integrated value is the crucial value. Calibration needs to spend minimal time in high N_2O formation regimes for both the TWC and the SCR. The reviewer suggested a little commentary would be appreciated.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer confirmed that substantial progress has been made, and especially liked the work on the relation of engine conditions (i.e., calibration) to the effectiveness of the NH_3 production. However, it is known that increasing the NO_x can also increase the N_2O. However, the rubber meets the road when the integrated system is tested under transient calibration conditions.

Reviewer 2:

The reviewer confirmed that the reviewers from the OEMs can greatly appreciate research, such as this, that considers the effect of aftertreatment technology on fuel economy in addition to emission control. These twin challenges must be met together. Also, including the effect of sulfur and other exhaust species on the overall catalyst efficiency is very important, because these exhaust components will be present going forward. In addition, bench reactor studies on the effects of regeneration methods helps provide guidance for the implementation of these passive NO_x control strategies to meet emissions standards. The reviewer pointed out that, however, all aspects of a catalyst system must be included in the assessment of fuel economy, and said that with respect to the TWC + NO_x storage, sulfur regeneration must be accounted for in the fuel economy calculation.

Reviewer 3:

The reviewer reported that there was good investigation into the effects of temperature, rich lambda, formulation, and sulfur effects on the NH_3 yield. It was pointed out there is a need to be clearer about the effects of the TWC formulation on the NH_3 production; for example, how much ceria was in the catalyst and what was the PGM loading. This reviewer also indicated it is hard to remember all the details from the table. The reviewer mentioned that there is a need to explore the CO and HC emissions more during the rich periods. The SCR catalyst will not convert CO during rich operation, and by definition one has to go rich over the TWC to generate NH_3. So there will be CO slip during the rich periods. It is suggested a multiple-step purge profile can mitigate the CO concerns. The reviewer remarked the project showed essentially 100% HC conversion during the rich periods. This reviewer then questioned if the project is really getting 100% steam reforming activity from the TWC, especially with the long purges. The reviewer brought to light the project would like to use a non-ceria TWC for NH_3 generation. But it was pointed out there must be some oxygen storage capacity (OSC) in the TWC for three-way activity, steam reforming and water-gas-shift activity, catalyst durability, and OBD diagnostics.

Reviewer 4:

The reviewer agreed that the evaluation of the catalysts and conditions chosen revealed a system that may work well for these engines. The role of rhodium was not revealed as clearly as one would hope, but one system worked well. It would be useful to have more understanding of the role of rhodium, say, in the selectivity of the system.

Question 3: Collaboration and Coordination with other institutions.

Reviewer 1:

The reviewer highlighted that excellent collaboration with strong OEM partner, national laboratory and consortium/university support through CLEERS is hard to improve. This reviewer also mentioned the project team has an outstanding, active consortium of OEMs and/or Tier 1 to solve this challenging system problem.

Reviewer 2:

The reviewer remarked that good collaboration between General Motors, ORNL, and Umicore.

Reviewer 3:

The reviewer pointed out that working directly with an OEM and catalyst supplier, as in this project, is a high value partnership. Input from these partners is essential for providing the correct testing conditions as well as appropriate catalyst technologies to explore for providing the twin benefits of fuel economy and emission control.

Reviewer 4:

The reviewer agreed that there is a good group of industry, national laboratory, and company researchers worked collaboratively in a constructive way.

Reviewer 5:

The reviewer cautioned that evidence of collaboration is relatively weak. Chris Rutland of UW has done considerable modeling of this type of catalyst and has made predictions of NH_3 and N_2O. This reviewer then suggested that it would be helpful if these results were at least compared to his model.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer observed an excellent approach to complete work on aging, bench flow catalyst optimization, and system efficiency work. More emphasis on system optimization models and approaches that are easily calibrated to for a particular application would make this outstanding.

Reviewer 2:

The reviewer reported that including the effects of fuel poisons on the performance of catalyst efficiency and selectivity is essential research for achieving increasingly stringent emissions standards. In addition, inclusion of emerging hybrid catalyst technologies to study their benefits or drawbacks is important to arrive at emission control systems that minimize the direct impacts on fuel economy and those that occur through greenhouse gas penalties. This reviewer then concluded that these hybrid technologies are quite possibly the enablers for meeting the emissions needs of the OEMs.

Reviewer 3:

The reviewer highlighted that an excellent plan for combined bench and engine work has been put forward.

Reviewer 4:

The reviewer observed that learning how to effectively calibrate the engine is a crucial goal.

Reviewer 5:

The reviewer suggested that there is a need to consider PM emissions. The need for a GPF would negate some of the FE improvement from lean operation and also add a lot of cost to the system. There is also a need more exploration on the HC and CO emissions during the rich periods. The HC emissions are more of a challenge than the NO_x emissions due to the extremely low levels allowed (for example, the cold start eats up most of the allowed HC), although the Tier 3 standards offer some flexibility with the HC and NO_x.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer said that general adoption of lean passenger cars would have huge impact on gasoline usage.

Reviewer 2:
The reviewer agreed that emission treatment of lean gasoline will provide petroleum displacement.

Reviewer 3:
The reviewer explained that the project incorporates work on the twin challenges of increasing fuel economy while meeting increasingly stringent Tier III and super low-emission vehicle emissions standards.

Reviewer 4:
The reviewer observed that successful lean burn aftertreatment strategies will enable an estimated near-term fuel savings of between 6% and 15% from lean burn combustion. Combustion technologies are available immediately, however, without effective after treatment, the benefit of these advanced combustion techniques cannot be realized in the production fleet.

Reviewer 5:
The reviewer stated that increased use of lean gasoline applications would decrease fuel usage.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer reported that good funding for excellent work. To achieve an outstanding effort, more funding and effort should be placed on system modeling and testing for NH_3 production to improve predictability of production and reduce complexity for OEM implementation.

Reviewer 2:
The reviewer expressed a need to see modeling added to this project.

Reviewer 3:
The reviewer pointed out that ORNL provided significant results with the resources the team has employed to align bench reactor results and engine dynamometer data. Very useful information has been provided for the resources dedicated to this work.

Reviewer 4:
The reviewer confirmed that the resources appear to be sufficient.

Neutron Imaging of Advanced Transportation Technologies: Todd Toops (Oak Ridge National Laboratory) - ace052

Presenter

Todd Toops, Oak Ridge National Laboratory.

Reviewer Sample Size

A total of five reviewers evaluated this project.

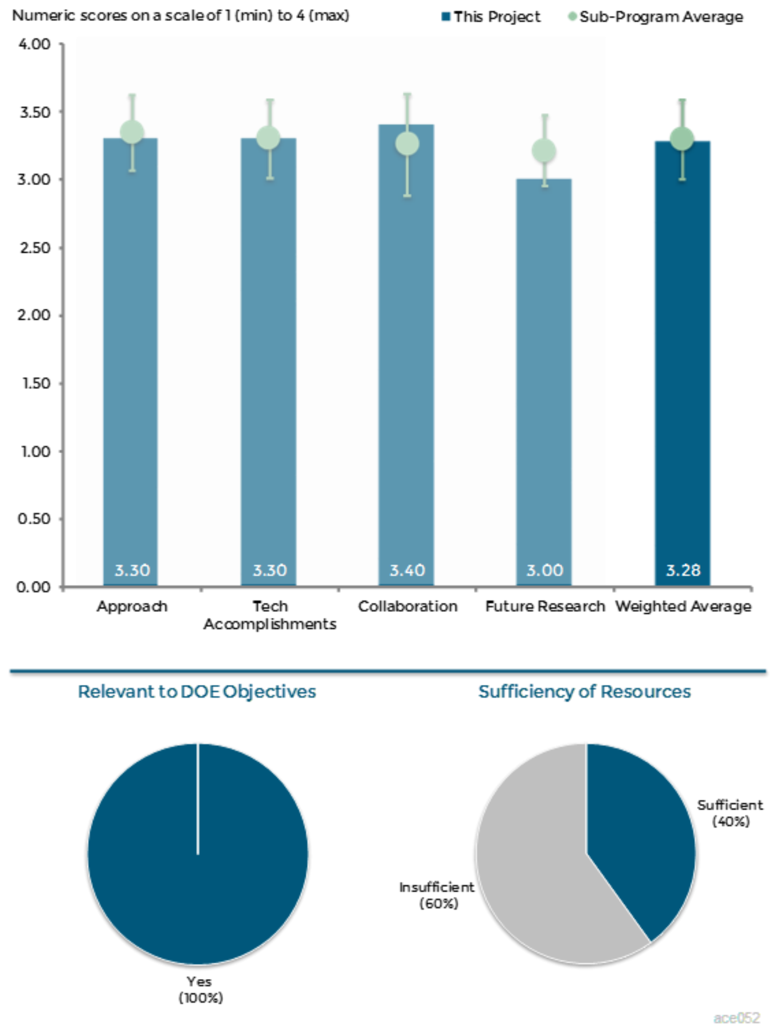

Figure 4-22 Neutron Imaging of Advanced Transportation Technologies: Todd Toops (Oak Ridge National Laboratory) – Advanced Combustion Engines

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer remarked that it was good to see gasoline injector related topics included in the work.

Reviewer 2:

The reviewer observed that the development of the neutron imaging as a complimentary tool is quite interesting, as non-destructive analysis or dynamic analysis of injectors (and particulate filters) to this level of understanding is unique. The method to develop these tools seems appropriate, which is evident in the test data that exists. What is not identified is the anticipated direct correlation to reduced fuel consumption with this tool, though it is understood that a quality improvement is possible when understanding lacquering of injectors or fouling of nozzles. This reviewer questioned how the efficiency improvements will be accomplished. The reviewer suggested that partnership with suppliers or OEMs to identify the top two or three issues with the technology could be done. To find a problem that needs solved related to efficiency or durability of components and then pursue that improvement would be interesting.

Reviewer 3:

The reviewer summarized that this is one of those unique projects that is focusing on bringing a new diagnostic for assessing the impact of clogging on injectors and aftertreatment devices. It has been exploratory in nature and the PI's approach has been with care given the possible environmental effects from the measurement technique. This reviewer then pointed out that much work is still needed to mature this diagnostic.

Reviewer 4:

The reviewer mentioned that this is a very interesting project that is using a non-destructive method to study injector characteristic DPF ash loading.

Reviewer 5:

The reviewer asked whether the project team has scoped out the limits of this unique diagnostic after five years of work on neutron imaging.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer reported that the technical accomplishments are very good, with impressive results. The reviewer expressed a reason of why not to mark this as outstanding, is because of the translation of tool development to overcoming barriers is not complete or unclear, and added the included questions of how this will improve particulate filter regeneration efficiency, fuel injection or combustion efficiency, and fuel injector or exhaust after-treatment system (EATS) component durability.

Reviewer 2:

The reviewer said that there were very interesting results from the fouled injector. The injection movie is exciting, but the reviewer is not sure that there is adequate resolution to be very useful. This reviewer then expressed a need to know what can be done to improve the detail in the images.

Reviewer 3:

The reviewer observed that the images generated from this diagnostic have been thought provoking and insightful for better understanding the capability of the current instrumentation. There is still much development work that is necessary including better resolution for studying clogged fuel injectors. This reviewer mentioned that the dribble portion of the work was interesting though the chamber pressure was very low compared to real world GDI applications and thus this observation may have been just a demonstration of the capability of this diagnostic.

Reviewer 4:

The reviewer remarked that characterizing a fouled injector was interesting, given the small size of the injector holes. Dynamic fluid flow videos captured inside the injector and coming out of it had low resolution, which makes it not very useful for model development. It is not very clear how any quantitative feedback for the modeling effort can be created. This reviewer expressed an agreement that evaluating ash loading is also a good application of this diagnostic technology.

Reviewer 5:

The reviewer pointed out that the non-destructive testing of clean and fouled injectors is very impressive and encouraging. Neutron imaging is certainly living up to its promise of being a non-destructive testing technique. The work on visualizing ash distribution within particulate filters is also revealing very interesting results. The reviewer indicated the visualization of the dynamic fuel injector is also interesting and questioned if the resolution can be improved.

Question 3: Collaboration and Coordination with other institutions.

Reviewer 1:

The reviewer highlighted the fact that there is excellent collaboration with industry, DOE Basic Energy Sciences (BES), suppliers, universities and national laboratories.

Reviewer 2:

The reviewer praised that the PI for having done a great job bringing together various partners to assess the capability of the diagnostic. Hopefully various partners will continue to supply test articles.

Reviewer 3:
The reviewer mentioned that it seems the an appropriate team is built to accomplish the development of the tool and first use, but now perhaps a consideration should be made to ensure a real problem is identified and solved, which may or may not require the addition of further members to the team.

Reviewer 4:
The reviewer said that it was good to see collaborations with industry partners.

Reviewer 5:
The reviewer reported that given this project aims to demonstrate a very unique and novel technique, sufficient collaboration exists.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer agreed that the proposed research is very good. The only suggestion is to consider including high-pressure common rail injectors in future studies.

Reviewer 2:
The reviewer mentioned that the proposed future work seems appropriate but does not seem concrete. The focus will be on fuel injectors and extreme conditions but perhaps this is not the direction this study should really be pursuing. This reviewer then suggested that the project could benefit from input from suppliers and manufacturers to identify a problem that needs to be understood and resolved, to ensure too much effort is not wasted on pursuing conditions that are not impacting today or future products.

Reviewer 3:
The reviewer pointed out that the need to identify areas of research that neutron imaging can uniquely access such as the particulate filter work. It is not clear yet if this is a good technique for imaging injector sprays.

Reviewer 4:
The reviewer remarked that some feedback on the cost of this neutron imaging diagnostic capability would be useful to understand. If this develops into a very reliable diagnostic capability, then the reviewer questioned how can industry injector and aftertreatment suppliers have access to this, or even own such equipment.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer affirmed that this project indirectly supports DOE objectives. It is an infant project that has potential to aid in the development of future injectors and aftertreatment devices for fuel efficient engines.

Reviewer 2:
The reviewer observed that fuel injectors and particulate filters are core components and improving upon them is vital for further efficiency gains.

Reviewer 3:
The reviewer confirmed that the project can help diagnose component behavior related to engine efficiency.

Reviewer 4:
The reviewer acknowledged that yes, this neutron imaging capability has several useful applications for characterizing engine injectors, which in turn would validate models required for understanding fundamental engine physics.

Reviewer 5:

This reviewer mentioned that the project addresses some of the risks associated with introducing some of the hardware for high efficiency engines.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented that the fiscal year 2015 presentation showed promising results. This effort should be expanded.

Reviewer 2:

The reviewer stated that the resource level seems appropriate.

Reviewer 3:

The reviewer indicated that there is a need to do more work in this area to identify other components that can be imaged and improve the image resolution.

Reviewer 4:

The reviewer suggested that possibly exploring high resolution measurement capability would be of value for future injector studies. This might be a good investment.

RCM Studies to Enable Gasoline-Relevant Low-Temperature Combustion: Scott Goldsborough (Argonne National Laboratory) - ace054

Presenter

Scott Goldsborough, Argonne National Laboratory.

Reviewer Sample Size

A total of four reviewers evaluated this project.

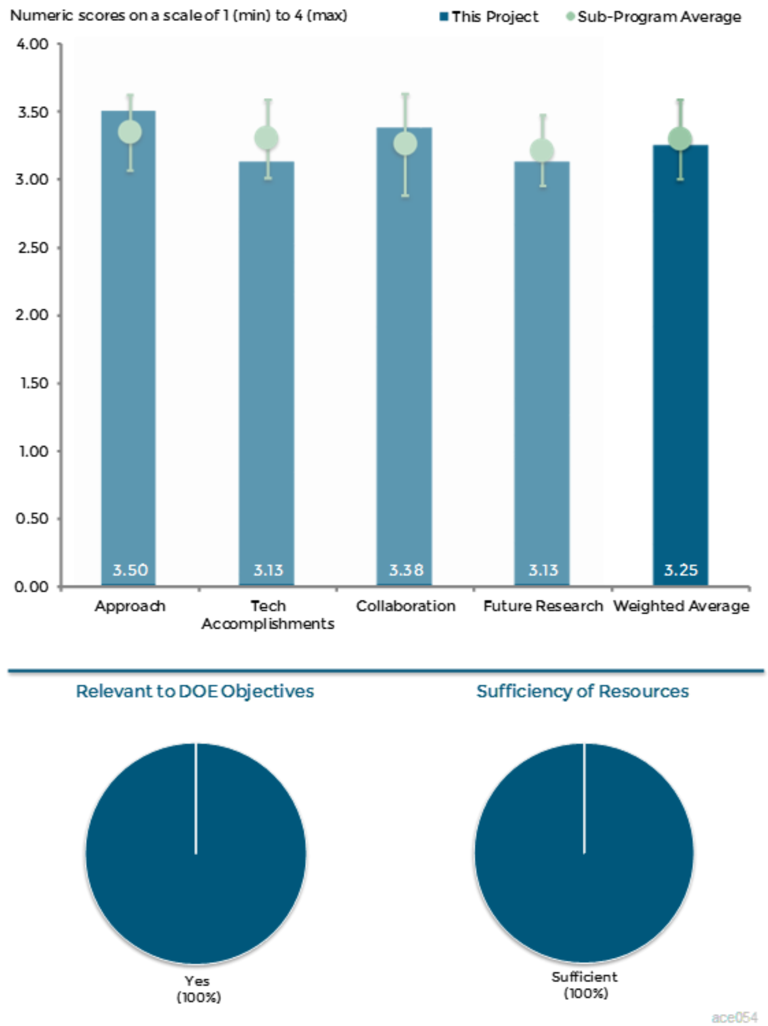

Figure 4-23 RCM Studies to Enable Gasoline-Relevant Low-Temperature Combustion: Scott Goldsborough (Argonne National Laboratory) – Advanced Combustion Engines

Reviewer 1:

The reviewer reported that the project has developed an excellent approach to overcome the technical barrier of inadequate chemical kinetic modeling capability for low-temperature combustion. The reviewer added that the novel data analysis (Uncertainty Quantification [UQ]/Global Sensitivity Analysis [GSA]) tools and new diagnostic capabilities effectively aid chemistry development via twin-piston RCM experiments. The reviewer stated that the project approach clearly addresses a significant technical barrier. The project is well designed in terms of systematic experiments and analysis for various fuels and surrogate blends and the approach seems feasible based on the progress so far. The reviewer noted that improved chemical kinetics models are a crucial and integral part of engine simulations needed to develop improved engines, the success of this endeavor will surely benefit the entire engine community.

Reviewer 2:

The reviewer observed that the use of machine RCM to acquire auto-ignition and fundamental data to develop chemical kinetics for gasoline fuel in conditions representative of internal combustion engine (ICE) is a good approach. The reviewer added that the project was able to acquire combustion data at pressure levels closer to actual in-cylinder pressure levels, which is important.

Reviewer 3:

The reviewer stated that this project involves the acquisition of data that will assist in the validation of chemical kinetic models as inputs to codes used to predict performance of transportation engines. The main tool is the RCM. The PI is a leader in this field and his RCM is outfitted with diagnostics that provide state of the art measurements. The reviewer added that the approach is to perform experiments on gasoline surrogate fuels and to obtain data that seems to be primarily ignition delay time, which the RCM is well positioned to obtain. As far as could be determined, the main output of the experiment that would be used in modeling is the ignition delay time (IDT). The reviewer said that the PI is in position to provide among the most accurate measurements of this type that modelers could use. In addition the reviewer commented that the PI is using the

RCM to assess performance of E0, E10 and E20. This is understandable because these fuels are currently being used. The reviewer noted that at the same time it would be appropriate to be more forward thinking and examine performance of other gasoline blends, such as gasoline with butanol (i.e., 0% butanol, 10% butanol, and 20% butanol).The reviewer added that the IDT is popularly used in codes that assess performance of kinetics. Such data are obtained in shock tubes, or RCMs as in this study, with temperature regimes that are complementary. The reviewer indicated that it is important to note that the IDT is but one of a number of metrics used to validate combustion chemistry. Others include laminar flame speed, extinction strain rate, etc. It would help if the PI could provide a context for the IDT and why the PI believes it is the most important, or very important. The reviewer observed that the plan for leveraging with the DOE Basic Energy Sciences (BES) researchers is excellent. More of this should be encouraged and similarly for other national laboratories.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer stated that the enhanced physical model to represent the RCM when calibrating chemical kinetics is important. The reviewer added that progress was made in acquiring and analyzing auto-ignition data sets.

Reviewer 2:

The reviewer indicated that progress took a hit this year as several components of the twin-piston RCM had to be redesigned to increase reliability and accuracy, but significant results were still obtained in several areas. The reviewer noted that key physical insights relevant to low-temperature combustion were obtained from experiments on gasoline/ethanol blends, and new UQ/GSA models were developed that are now tractable via various software tools. The reviewer added that areas of challenges and improvements in terms of accounting for the correlated uncertainties are also properly identified. All the above technical accomplishments are clearly aligned to the overall project objectives of improving chemical kinetic modeling capability, and the overall U.S. Department of Energy (DOE) goal of predictive engine simulations.

Reviewer 3:

The reviewer said that there was some connection to engine level combustion. The reviewer stated that the project team needs to continue applying techniques and results to engine level attributes.

Reviewer 4:

The reviewer stated that it is very interesting that there is no difference of the IDTs in the high temperature regimes, for example, less than 900,000, while significant differences are found at lower temperatures. The reviewer asked is this result consistent with performance of these fuels in engine tests, for example, for other metrics. The reviewer added that it was not clear precisely what code is being used in the CHEMKIN simulation and what rationales would be brought to bear to reduce the combustion chemistry from 7,000+ steps to a more computationally manageable number. The reviewer asked if the code (whatever it is) could handle 7,000 reactions in a reasonable computer time. In addition the reviewer asked are special computers needed to perform the calculations (photos of what look like Lawrence Livermore National Laboratory (LLNL) computers were included in the slides but it was not clear what these were). The reviewer asked what the computational time was. The reviewer also asked what the computer platform was. The reviewer noted a fast kinetic solver but it was not clear what this was. The reviewer then asked is developing such a solver part of the work or does it already exist. The reviewer also noted constant volume simulations where the simulations were compared with measurements. The reviewer asked what the relevance of a constant volume configuration is here. The reviewer also asked if the constant volume configuration is to provide a fundamental environment for combustion or is there more to it. In addition the reviewer asked would the chemistry validated with constant volume or RCM data carry over to the engine environment where a different code would presumably be used, for example, KIVA, Converge, etc. The reviewer noted that the iso-octane simulations show a rather strong effect of preheating the gas (for example, the initial temperature), this needs to be explained.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer remarked that the workshop concept, inspired by the ECN no doubt, is an excellent way to engage labs, universities, energy companies, and engine makers. The action to expand the workshop to include some of the other experimental devices important for kinetics research (shock tubes, etc.) is very commendable and addresses a reservation that this reviewer voiced last year. The reviewer added that beyond the workshops, there is significant collaboration within the project on a more detailed level.

Reviewer 2:

The reviewer commented that Argonne National Laboratory (ANL) leads the international RCM workshops which enables collaboration and standardization of RCM experiments for kinetics development.

Reviewer 3:

The reviewer indicated that this project has a lot of collaborators. The PI has developed successful workshops based on RCM data. Presumably at these workshops some of the questions noted previously might have been addressed and the reviewer asked if the questions were addressed. The reviewer noted that the input these collaborators provide was not clearly stated beyond a few sentences. For example, reviewers read mechanism reduction for Northeastern, gasoline surrogate model for LLNL, fuels, fuel models for KAUST, etc.. The reviewer stated that these words do not provide much useful information for how their inputs are critical to the success of this project. The reviewer would like to know precisely what these organizations are substantively contributing to this project, and how necessary their input is.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that the future work has been planned effectively to improve the model capabilities and planning additional RCM experiments with sufficient level of detail (step-by-step procedures) addressed; however, the reviewer said that the individual timelines of the proposed action items should be more clearly defined, and future work should also look into quantitative comparisons of the improved chemical kinetics model with the existing ones.

Reviewer 2:

The reviewer indicated that further RCM experiments to model gasoline and gasoline surrogates were needed.

Reviewer 3:

The reviewer reported that for future work the PI wants to study a low order surrogate blend that can contain up to 10 components, though it would seem that 10 is not a particularly low order surrogate. The reviewer added that it was not clear what particular surrogate blend was targeted for study. A five-component blend is noted, though the rationale for its selection was not given. The reviewer indicated that the future work notes the need to improve the capabilities of gasoline surrogates. However, the plan to this end is not described in any substantive detail. Presumably, it would involve measuring the IDT, predicting it using some sort of code of the RCM, and comparing the results. The reviewer asked, but then what. The reviewer then asked what the plan is going forward if the code does not well predict the IDT data. The reviewer also asked what code inputs will be adjusted and how. The reviewer recommended that the PI give consideration to a more traditional surrogate, iso-octane/heptane/toluene with variations of the mixture fractions covering regimes of interest (the project team already has iso-octane data). The chemistry of such a blend should be known. The future plan mention some collaborators, for example, naphthenes [KAUST] for multicomponent blends. The reviewer asked what does this mean. Regarding fuels for advanced combustion engines (FACE) fuels with LLNL, the reviewer asked what does this mean. The reviewer then asked if these organizations are going to do some experiments. The reviewer also asked what their role is in the tasks going forward. The reviewer explained that for a given fuel system it would be illustrative to put the PI's IDT data from the RCM on the same plot as shock tube data of the same fuel system.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that this fundamental research is required to develop combustion models.

Reviewer 2:

The reviewer commented that better kinetics will lead to better engine simulations to aid in the design of more efficient engines using less petroleum.

Reviewer 3:

The reviewer stated that the RCM is a valuable tool that provides IDT data to validate the combustion chemistry of surrogates for real transportation fuels. The reviewer added that a close link to developers of simulation codes (KIVA, Converge, etc.) benefits this work because the IDT data are ostensibly going to be used to improve surrogate fuel chemistry, and such chemistry is the input to simulation. The reviewer noted that it is good that the PI is working toward using IDT data to evaluate surrogate chemistry for use in an engine solver.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer reported that the resources seem to be adequate. The reviewer added that the comparatively large ($500,000) cost is likely due to the experimental emphasis of this project, though further details would be useful to better understand what the costs are being used for.

Reviewer 2:

The reviewer said that the resources seem adequate.

Fuel-Neutral Studies of Particulate Matter Transport Emissions: Mark Stewart (Pacific Northwest National Laboratory) - ace056

Presenter

Mark Stewart, Pacific Northwest National Laboratory.

Reviewer Sample Size

A total of two reviewers evaluated this project.

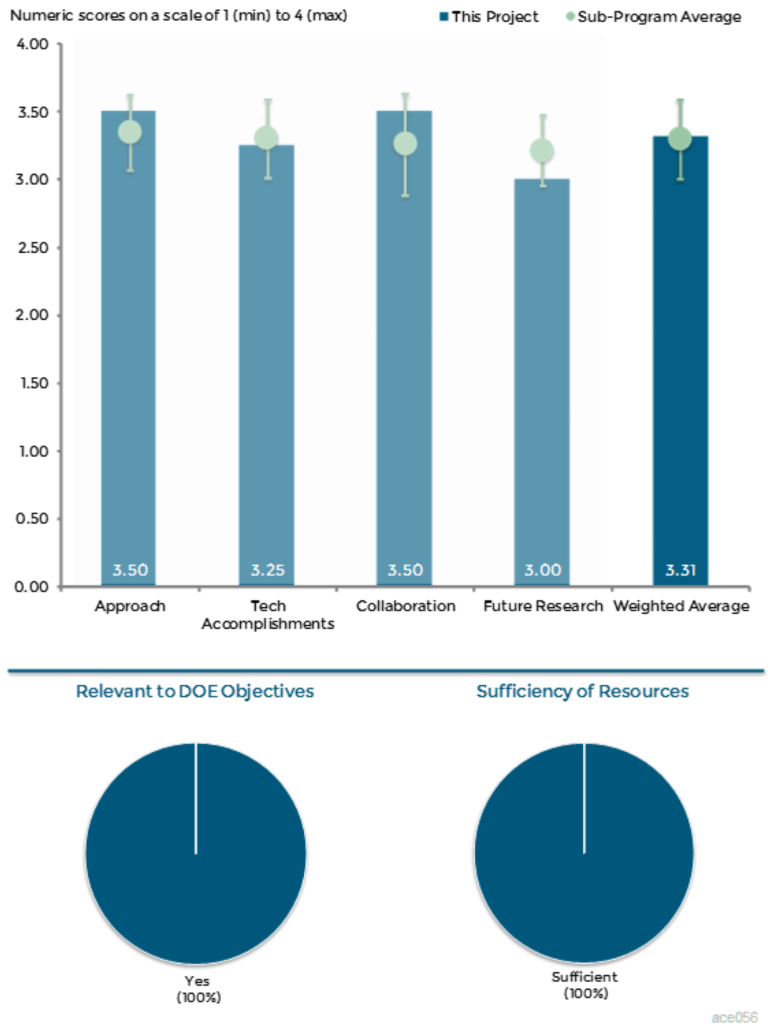

Figure 4-24 Fuel-Neutral Studies of Particulate Matter Transport Emissions: Mark Stewart (Pacific Northwest National Laboratory) – Advanced Combustion Engines

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that the work with Engine Research Center (ERC) is impressive. Transfer of equipment to engines and fuels expert testing is world-class. Leveraging ERC's wafer methods also important. The reviewer added that the critical equivalence ratio approach is interesting and important. The reviewer noted that the particle characterization studies seem to address key properties - size, solid content, SOF.

Reviewer 2:

The reviewer indicated that this project takes a comprehensive approach in characterizing the particulate matters for gasoline direct injection (GDI) engines using various fuels and at various engine operating conditions. The reviewer added that the explanation of using non-catalyst-coated filter for the study is reasonable for this stage of the study. Study and findings could provide guidance for future design and operation of gasoline particulate filters (GPF).

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer stated that good progress has been made with regards to the experimental work. The reviewer reported that the technical accomplishments in this area have been impressive. There was little mention of modeling work. The reviewer added that it is not clear to what level the experimental results have improved the feasibility or provided direction of change in the proposed model.

Reviewer 2:

The reviewer remarked that particulates are complex. The reviewer explained that the industry is just now entering a gasoline particulate concern. These fundamental studies on gasoline particulate drivers are important to guide future direction. The reviewer added that critical equivalency ratio data is an interesting approach and confirms the polycyclic aromatic hydrocarbon (PAH) particulate matter (PM) precursor theories established years ago. (California Air Resources Board [CARB] limits PAHs for this reason.) The reviewer noted that there was interesting base-knowledge work on particulate characteristics versus fuel and operating conditions. This data will help guide public policy risks for unfiltered exhaust and fuel directions. Results show that engine operating conditions might have an equal or greater impact on composition and size than fuels. The reviewer stated that the filter results are interesting, but not surprising, yet. The reviewer indicated that the results confirm much of the understanding developed on diesel. The reviewer added that work on filter properties versus performance will be important, there is a good range of filter properties. The reviewer acknowledged that shape versus size filtration efficiency for one filter type is interesting.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer remarked that Pacific Northwest National Laboratory (PNNL) and ERC working with filter suppliers is excellent. The reviewer added that there was close collaboration between two key parties. The reviewer said it does not get better than working together on site. The reviewer added that communication with filter suppliers is good.

Reviewer 2:

The reviewer said collaboration and coordination with General Motors (GM) and UW ERC have been good.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer noted that the proposed future work is in the right direction. This is a multi-variable problem, and there is an infinite number of combinations. The reviewer added that a careful planning and statistical design of experiments would speed up the project.

Reviewer 2:

The reviewer stated that the continuation of efforts seems logical. When looking at filter effects, start with very different filters to see if GPF properties have an impact. The reviewer pointed out one key oversight, all gasoline engines will have a catalyst, either before or on the GPF. The reviewer asked if the organics are taken out by the catalyst or are they on the particles prior to entering the catalyst. The reviewer also asked what enters the environment if a GPF is not used. The reviewer added that the project team should install a TWC and then characterize the PM composition for representative fuels. It is easy and will make a big contribution to public risk.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated that GDIs are coming in a big way, fuels may also be changing, and particles are a key concern. The reviewer added that this study provides base understanding.

Reviewer 2:

The reviewer commented that the findings from this study could help GDI engines in meeting future emissions standard. The reviewer added that GDI engines improve fuel economy (FE), which would support DOE objectives of petroleum displacement.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer indicated that $200,000 is not much, but the team has delivered. The reviewer added given this and the future plans, resources seem adequate.

Reviewer 2:

The reviewer stated funding seems to be adequate for the remaining tasks.

Cummins SuperTruck Program Technology and System Level Demonstration of Highly Efficient and Clean, Diesel Powered Class 8 Trucks: David Koeberlein (Cummins, Inc.) - ace057

Presenter

David Koeberlein, Cummins, Inc.

Reviewer Sample Size

A total of seven reviewers evaluated this project.

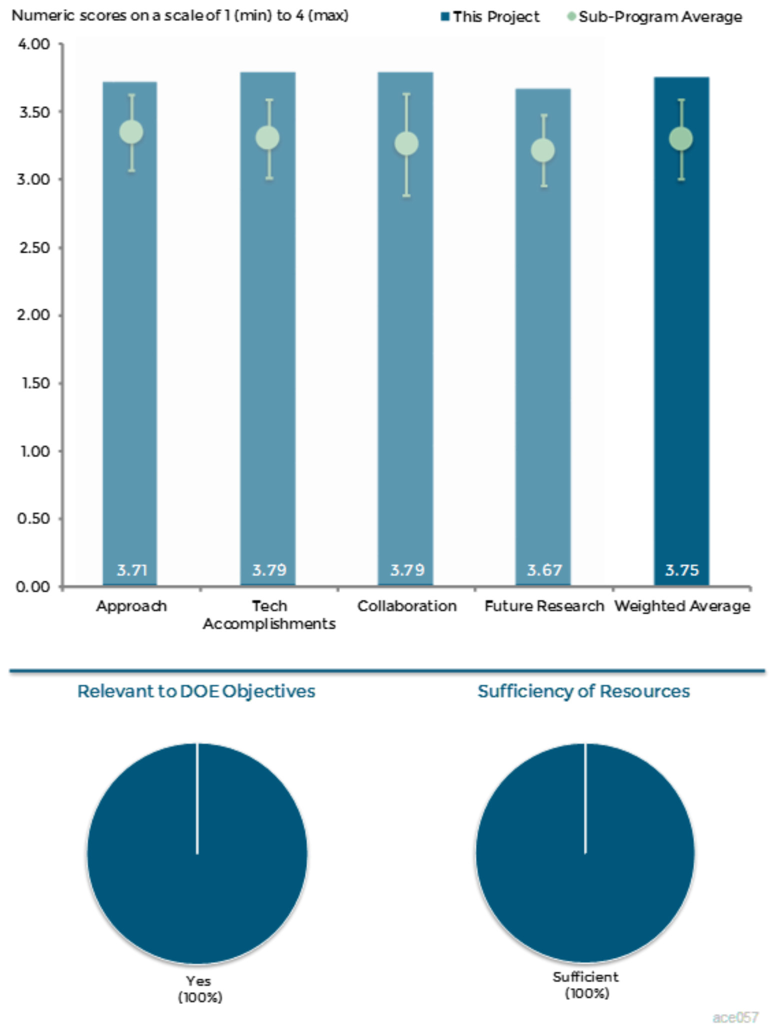

Figure 4-25 Cummins SuperTruck Program Technology and System Level Demonstration of Highly Efficient and Clean, Diesel Powered Class 8 Trucks: David Koeberlein (Cummins, Inc.) – Advanced Combustion Engines

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commented that using dual fuel for commercial vehicles would be extremely challenging because of high load limit even at 40% load as well as super–high hydrocarbon (HC) and carbon monoxide (CO). This would not be a practical approach; however, the reviewer is glad to see that this approach is downgraded and more reliant on the conventional approach. The program provides a parallel approach to minimize the program risk. The reviewer added excellent job.

Reviewer 2:

The reviewer said that this approach was comprehensive and considered all possible sources of fuel economy gain. The reviewer added that the project stayed on plan and was solidly successful. The reviewer also said it resulted in a very good test vehicle.

Reviewer 3:

The reviewer stated that Cummins demonstrated greater than 50% BTE without WHR. This is a tremendous achievement and was only previously possible in large, slow-speed diesel engines.

Reviewer 4:

The reviewer said t ruck and 50% BTE g goals were exceeded, so obviously the approach was successful. Start with analysis, and plug away at easiest then hardest. The reviewer added that in retrospect, 51% BTE could have been achieved without waste heat recovery (WHR) and subsequent vehicle changes. The reviewer stated that for the 55% BTE approach diesel seems better than dual fuel. Excellent refinement and optimization. The reviewer asked with regards to ethanol dual fuel, if petroleum displacement was really better than BTE reduction. The goal changed, and this needs re-evaluation with regards to greenhouse gas (GHG) impact.

Reviewer 5:

The reviewer indicated that the project team had an excellent approach for current period 55% BTE target pathway includes consideration of diesel only approach and dual fuel and utilizes industry state of the art computational fluid dynamics (CFD) analysis coupled with a limited test program.

Reviewer 6:

The reviewer stated that the Cummins team has successfully identified and implemented a combination of technologies that resulted in not only meeting but exceeding the DOE program goals. The project team has successfully demonstrated a greater than 50% brake thermal efficiency (BTE) engine. Additionally, the reviewer said by working with their partners, the project team implemented aerodynamic technologies and rolling resistance reduction technologies in addition to a host of other technologies to be able to exceed the set goal of 50% improvement in freight efficiency. Moreover, the team has identified a technology pathway towards achieving a 55% BTE engine. The reviewer indicated that overall this is a very successful program wherein the technical barriers were addressed early in the program, and a technology pathway was identified to address them; however, considering the fact that this is a 15 minute review wherein the presenter does not share all the details with the review panel, the reviewer believed that Cummins has projected extremely optimistic values in being able to achieve a 55% BTE engine.

Reviewer 7:

The reviewer indicated that this could have been an outstanding rating, but many details were not divulged, and this reviewer is not sure whether it is due to time limitation, or whether there were intellectual property (IP) issues preventing disclosure. For example, the details were missing for the injection rate shaping approach on Slide 14, and the new CFD tool details on Slide 18. Without the details, the approach cannot be judged.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer said all are excellent or outstanding. WHR optimization, thermal losses, combustion improvement, analyses. The reviewer added that the truck design seems practical. Impressive engine and vehicle improvements combined to exceed goals.

Reviewer 2:

The reviewer stated all project targets were met, all were delivered on schedule. This was a very impressive accomplishment.

Reviewer 3:

The reviewer stated that there was excellent technical progress in that pathway for 55% BTE is not only being modeled but tested on dyno engines. Base program objectives of 50% BTE contributing to freight efficiency targets completed in previous years. The reviewer added that the data is supportive of progress. Effective engine out emission data and temperatures to meet emission standards would rate in outstanding category.

Reviewer 4:

The reviewer stated that waste heat recovery was taken from a concept to a marketable device which the reviewer is sure the industry will see on future products from both Cummins and other users.

Reviewer 5:

The reviewer remarked that a lot of work has been done with Approach 1 even though Approach 2 is not practical due to dual fuel assumptions. The results do show the possibility to achieve the 55% goal.

Reviewer 6:

The reviewer commented that Cummins has used a combination of technologies to improve engine efficiency: engine down-speed, high conversion efficiency NO_x aftertreatment, and parasitic power reductions. Additionally, the project team has worked with their partners to identify technologies to further improve vehicle efficiency: improved aerodynamics, reduced rolling resistance tires, significant vehicle reduction. The reviewer added that the project team identified a technology pathway in achieving 55% BTE that includes optimized bowl, better fuel injection system, thermal barrier coating, and waste heat recovery. If one were to believe the numbers shown in the presentation, the team has achieved all the major goals of this DOE program.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer indicated that there was excellent collaboration with national laboratories, suppliers, and universities. Dual fuel consortium has potential to be outstanding.

Reviewer 2:

The reviewer remarked that Cummins did an outstanding job coordinating the design and function of engine systems with the cab design and working with their partners to reduce road loads (aerodynamics, rolling resistance) and auxiliary loads.

Reviewer 3:

The reviewer commented that many collaborators and excellent communications and contributions. The project management is outstanding.

Reviewer 4:

The reviewer said it has been great by working with so many partners under this program.

Reviewer 5:

The reviewer stated that there was no evidence that there were problems with any of the suppliers and collaborators. The managerial skills that were required to keep all those suppliers balanced is impressive.

Reviewer 6:

The reviewer indicated that the project has worked with a truck manufacturer, Peterbilt, in addition to having worked with at least eight other Tier-I suppliers. By all means the team has achieved the main goal of this American Recovery and Reinvestment Act (ARRA) program, that of spurring economic activity. The reviewer added that the project team has evaluated ethanol compression ignition (dual fuel activity) with Oak Ridge National Laboratory, which to a large extent has foreseen a technical barrier. An alternate pathway is recommended. The reviewer stated that a better university participation is also recommended.

Reviewer 7:

The reviewer stated that this project benefited from a good team of multi-faceted organizations. Last year’s comment still applies in that the presentation does not detail the contributions of all the partners.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer indicated that this project has been completed and closed out. It is a good demonstration of DOE investment into technology development that can contribute and in some cases actually be implemented into production. The reviewer added that the DOE should continue to fund cost-shared projects like this successful one. One aspect of the project, the alternate dual fuel approach, is being continued beyond the SuperTruck program, funded by other sources.

Reviewer 2:
The reviewer noted that if the DOE is considering a follow-up program, continuation of the present effort is highly recommended. This is the only program wherein various candidate technologies are evaluated for potential integration into a future product; however, the DOE should find a pathway to make all the findings from such an effort publicly available.

Reviewer 3:
The reviewer noted that the project is wrapping up in 2015; however, the funding opportunity announcement (FOA) and the effort are models for advancing the industry toward step function real world FE gains in the commercial truck sector. The reviewer added that future possibilities for funding and effort will be high-value proposition approaches for Class 8 trucks from SuperTruck and the next generation Class 8 truck or possibly the next priority in freight fuel consumption.

Reviewer 4:
The reviewer stated that a future project of this magnitude with Cummins would be of solid value.

Reviewer 5:
The reviewer said project complete.

Reviewer 6:
The reviewer said that the program should be finished by now.

Reviewer 7:
The reviewer commented that dual fuel 55% BTE approach seems much riskier and difficult than diesel; however, GHG impact with E85 may be beneficial. Petroleum displacement does not seem to matter much anymore (despite DOE's contention). The reviewer added that going forward, it seems likely that 55% BTE approaches will begin consolidating among program participants. 50% BTE saw different approaches. 55% needs everything.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer stated absolutely, this project supports the overall DOE objectives of petroleum displacement with significant improvement on both engine and vehicle. The reviewer added that the project is well done.

Reviewer 2:
The reviewer stated that Cummins reached all the goals set by the project.

Reviewer 3:
The reviewer remarked that the super truck goals of 50 BTE were demonstrated and 55% BTE pathway was clearly present options for near term, significant fuel consumption reduction for Class 8 trucks.

Reviewer 4:
The reviewer commented that both the demonstration of efficiency gains and the alternate fuel (petroleum displacement) were in support of DOE goals.

Reviewer 5:
The reviewer stated that in this project Cummins has identified a technical pathway towards substantial efficiency improvement and subsequently implemented and tested engines, and the vehicle as a whole. While this just proves a potential pathway for petroleum use or reduction by trucking industry, it is yet to be implemented into commercial production. The reviewer added that previous experiences elsewhere in DOE programs show that engine companies can demonstrate engine builds with excellent benefits, however, they are very reluctant to introduce any of them into the market citing durability issues and customer preference. The

true objective of the DOE program will be realized when at least some of these efficiency enhancing technologies will find their way into commercial products.

Reviewer 6:

The reviewer said obvious.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that the project team accomplished their goal on time.

Reviewer 2:

The reviewer commented that the project budget and cost share contributions were quite significant and benefited from ARRA funds at the outset. The high level of funding generated high expectations, but the project delivered and results lived up to expectations.

SuperTruck Program: Engine Project Review: Sandeep Singh (Detroit Diesel) - ace058

Presenter

Sandeep Singh, Detroit Diesel.

Reviewer Sample Size

A total of seven reviewers evaluated this project.

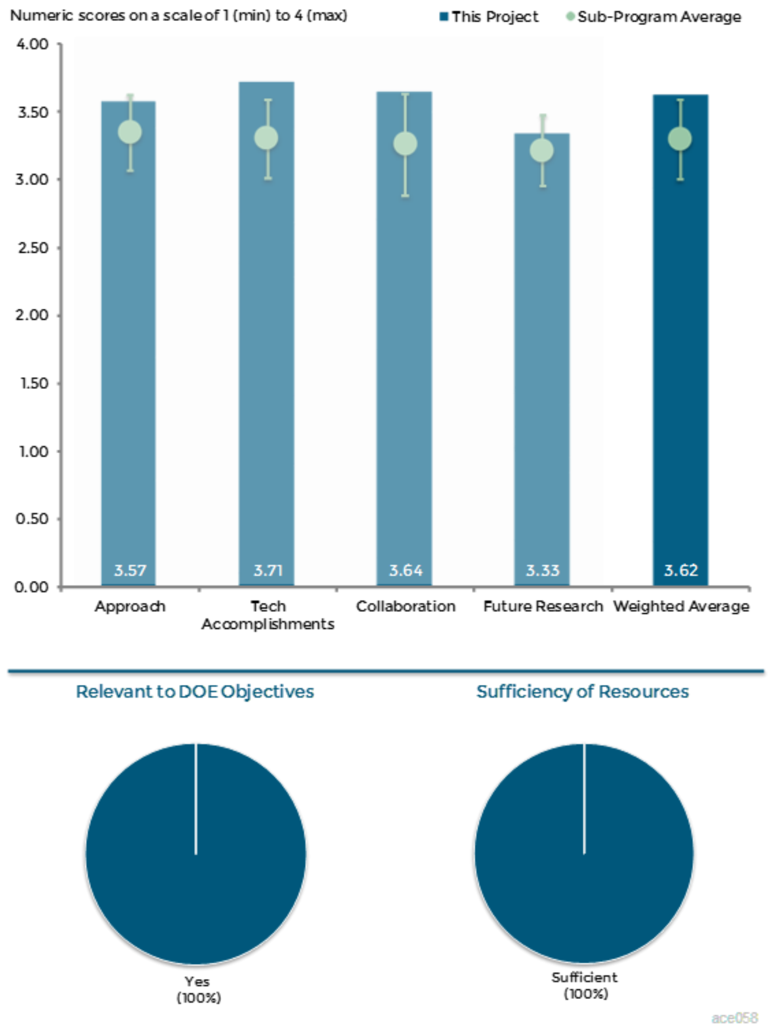

Figure 4-26 SuperTruck Program: Engine Project Review: Sandeep Singh (Detroit Diesel) – Advanced Combustion Engines

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that this project, like several other SuperTruck projects, is complete and was a solid success. It used the bit by bit process which characterized all the projects. The reviewer has noted a consistent successful progression of project results based on participating in previous project review cycles.

Reviewer 2:

The reviewer commented that early in the program the Detroit Diesel Corporation (DDC) team identified a technology mix, associated potential barriers and adequately addressed them through a developmental program.

Reviewer 3:

The reviewer indicated that 48% BTE without WHR is a commendable achievement and should be directly applicable to production engines.

Reviewer 4:

The reviewer noted that the project team had an excellent approach to meet program objectives for 50% BTE on a diesel only Class 8 truck.

Reviewer 5:

The reviewer indicated that the project exceeded goals, so excellent approach. 48% BTE on core engine, then WHR addition. The reviewer added that there were lots of optimization and incremental improvements and there were good analyses. For 55% BTE, electronic waste heat recovery (eWHR) feeds well with potential hybridization and solar. Conservative benefits are appropriate. The reviewer added that dual fuel approach with natural gas (NG) seems reasonable, 3.8-5.7% BTE points impressive out of the box; however, the reviewer would prefer to see a more conventional approach.

Reviewer 6:

The reviewer stated that the approach in this project has been to explore all possible pathways for improving the BTE of the ICE. As a result, the goals were all met and nearly all of the barriers were surpassed. The reviewer added that the project is an extremely successful program that is now closed out. The analysis of NO_x aftertreatment operating cost was a good grounding exercise to keep customer acceptance in focus.

Reviewer 7:

The reviewer stated that using 11 liter engine is too risky due to reliability issue. This approach has a little or no chance to be commercialized in 10 years but it does serve the program objective, nicely done. The reviewer added that using dual fuel would not work for commercial vehicle due to high loads. This approach cannot handle the peak cylinder pressure and rise even at 10 bar of brake mean effective pressure (BMEP). In addition, the reviewer noted that the use of NG as an alternative fuel for dual-fuel option would create many issues, such as super-high HC, methane (CH_4), and CO. It is extremely challenging to remove CH_4 under normal temperature. The approach should address this issue.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer stated that the project team has a demo truck that is getting significant notice. WHR was evaluated for this vehicle, but not to the sophistication that Cummins has; however, the hallmark of this approach was the predictive engine control. The reviewer believed that was a very solid success and can be or perhaps is already being commercialized.

Reviewer 2:

The reviewer noted that for engine improvement the project team has used a technology mix of WHR, parasitic loss reduction, low-energy intensive aftertreatment system, including various combustion system developments that lead to down-sizing and down-speeding. The reviewer added that vehicle improvements included reduced aerodynamic drag, low-rolling resistance tires, and light-weighting. As a result the project team was able to achieve 50.2% engine BTE, as well as greater than 50% improvement in vehicle fuel efficiency as a whole. The reviewer also stated that between 2014 and 2015 AMR presentations, DDC has shared all of their test results to a large extent to establish some amount of credibility, unlike other awardees. The project team also gives an honest projection of the capabilities of candidate technologies in their ability to help achieve the 55% BTE goal.

Reviewer 3:

The reviewer reported that six BTE points (42 to 48%) showing a variety of approaches. Integrated and done very well. The reviewer added that predictive controls were different and effective; interesting on NO_x and selective catalytic reduction (SCR) temperature. The project team pushed de-NO_x technology. The reviewer stated that for the 55% BTE, Turbo matching and EGR balance was done well and balanced with SCR capability, especially considering CARB directions. The reviewer stated reasonable analyses on dual fuel approach.

Reviewer 4:

The reviewer explained that only a couple of the technical barriers were not overcome, but the project goals were all met or exceeded. The demonstration of petroleum replacement with the dual-fueled NG/diesel pilot was interesting, and an impressive replacement percentage.

Reviewer 5:

The reviewer indicated that even though dual fuel still has a lot of hurdles to overcome, application of this approach to a heavy-duty (HD) engine is encouraging. The reviewer looks forward to seeing the results.

Reviewer 6:

The reviewer stated that the project achieved 50% BTE and have scoped out pathway for 55% with dual fuel approach. For outstanding, clear definition of engine out emissions and engine performance results could be presented.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer commented that a project as complex as this requires major project management skills. Detroit Diesel has consistently employed them to reach their goal. The reviewer believed Kevin Sisken initiated the project and was consistently effective.

Reviewer 2:

The reviewer indicated that there was outstanding collaboration with supplier companies and universities in all aspects including engine, after treatment, hybrid and vehicle systems.

Reviewer 3:

The reviewer commented that this project benefited from a very comprehensive team that was assembled and managed. It was very well coordinated to achieve the program goals.

Reviewer 4:

The reviewer reported that the DDC lists a total of 21 partners in this effort who either as subcontractors or part suppliers have helped the project achieve the program goals; however, primarily, the project team has worked with Oak Ridge National Laboratory (ORNL) in evaluating NG-diesel dual-fuel combination that has shown excellent benefits in terms of efficiency gains. The reviewer said that in fact it is one of the prime candidates in support of achieving 55% BTE engine. Early in the program the team worked with Massachusetts Institute of Technology (MIT) to identify ways to reduce friction at the piston-liner interface.

Reviewer 5:

The reviewer stated that impressive collaborations resulted in different approaches and good results. Model-based control different. The reviewer added that it was nice to see thermal - lube oil work, but much of the collaboration was internal.

Reviewer 6:

The reviewer reported that working with ORNL is encouraging.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that recommending Detroit Diesel for a future program of this scope would be very effective.

Reviewer 2:

The reviewer said there was an excellent approach to future dual fuel work with a national laboratory and supplier community support.

Reviewer 3:

The reviewer reported that it was nice to see a different approach versus Cummins to 55% BTE with dual-fuel approach and more control. Nice analyses on capabilities of conventional combustion. The reviewer was not too concerned about CH_4 emissions, as light-off temperatures are coming down. Proposal needs to contemplate this, given emerging GHG importance.

Reviewer 4:

The reviewer stated that DDC did evaluate WHR thoroughly to give an honest projection of maximum efficiency gain achievable using that technology. As a result DDC projects a technology mix centered around NG-diesel duel fuel mix in order to achieve 55% BTE. The reviewer added that it is highly recommended that DOE follow-up the present program in the future. The industry finds that this is the only effort wherein various technologies are evaluated for potential integration into future products. The reviewer noted that the researchers have been very forthcoming in sharing technical details to provide an honest assessment. This trend should be encouraged in the future.

Reviewer 5:

The reviewer commented that the project has been closed out. Some research will continue from other funding sources beyond this project. The reviewer added that this project was a good demonstration of DOE making a good investment to demonstrate and advance technologies that can be commercialized.

Reviewer 6:

The reviewer said the project was complete.

Reviewer 7:

The reviewer was not quite convinced if the approach is able to achieve 55% goal with dual fuel approach. It would be better if a parallel approach can be proposed in reducing the overall program risk.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer said yes, this project supports the overall DOE objectives of petroleum displacement with significant improvement on both the engine and vehicle.

Reviewer 2:

The reviewer stated that SuperTruck goals are clearly tailored to petroleum displacement and this project has exceeded all program goals.

Reviewer 3:

The reviewer indicated that the project met the goals of 50% BTE engine efficiency and demonstrated the pathway to 55% BTE. These will reduce the consumption of petroleum in the United States.

Reviewer 4:

The reviewer stated that over the road Class 8 diesels consume a majority of the petroleum used in the transportation sector. These improvements in fuel consumption will have a significant effect on the bottom line of transportation fuel consumption.

Reviewer 5:

The reviewer indicated that the award to DDC has resulted in an honest assessment of various candidate technologies to result in a technology mix leading to a 50.1% BTE engine. Also, a vehicle with greater than 68% freight fuel efficiency improvement has been demonstrated. The reviewer added that while this is very encouraging, the true benefit of petroleum displacement will only be achieved if some or all of the contributing efficiency enhancement technologies find their way to commercial products. As witnessed in previous DOE funded program, demonstrated engine builds never make it into production. The reviewer said some of the cited reasons being cost, customer acceptance and durability.

Reviewer 6:

The reviewer said obvious.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer said the project team successfully completed project.

Reviewer 2:
The reviewer noted that the project was funded at a very generous level (partial ARRA funding), so expectations were high, but achievements did not fall short of expectations.

Reviewer 3:
The reviewer reported that the goals were achieved on budget.

Development and Demonstration of a Fuel-Efficient Class 8 Tractor and Trailer: Russ Zukouski (Navistar International Corporation) - ace059

Presenter

Russ Zukouski, Navistar International Corporation.

Reviewer Sample Size

A total of six reviewers evaluated this project.

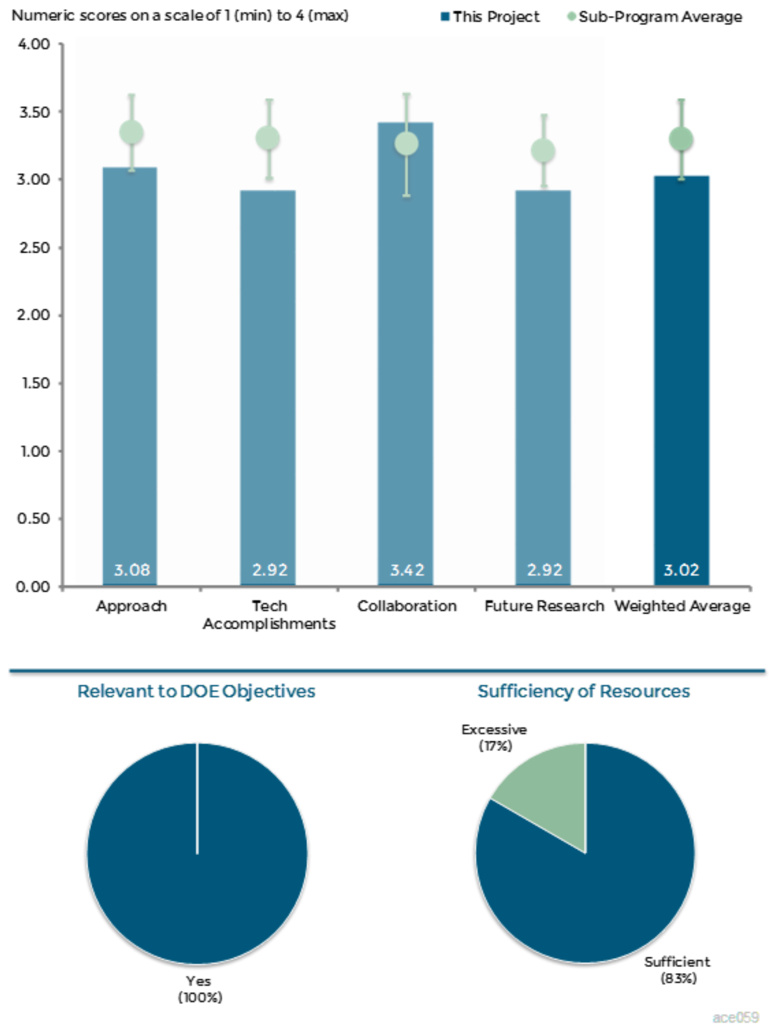

Figure 4-27 Development and Demonstration of a Fuel-Efficient Class 8 Tractor and Trailer: Russ Zukouski (Navistar International Corporation) – Advanced Combustion Engines

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer said that achieving greater than 48% BTE prior to WHR is commendable.

Reviewer 2:

The reviewer indicated that Navistar did an excellent job in developing a program that at the outset clearly identified the goals, and developed a developmental program that also catered to the customer needs. The technology mix identified and pursued towards 50% BTE engine includes down speeding, parasitic loss reduction, advanced combustion development, and gas flow optimization. The reviewer added that the technology mix identified towards 55% BTE system includes organic Rankine cycle ORC, driven turbo as well as some amount of dual-fuel technologies; however, Navistar does not seem to address the third objective altogether, for example, of demonstrating a vehicle with greater than 50% improved fuel efficiency.

Reviewer 3:

The reviewer reported that it was nice to see different approaches from others, variable valve actuation (VVA), parasitic reduction. Nice distribution of BTE impacts over levers with near-equal contributions to 50% BTE. The reviewer would like to see 50% BTE without WHR using driven turbo.

Reviewer 4:

The reviewer said that the project team had a solid approach to achieving SuperTruck goals with building block technologies. Usual suspects have been identified; WHR, advanced combustion, VVA, parasitic reductions and good approach to use CFD plus dyno and leveraging Tier 1 supplier and national laboratory capabilities.

Reviewer 5:

The reviewer stated that it is not clear how an engine can achieve 50% goal without WHR with Rankine cycle. From 48.3 to 50%, mainly relying on the technologies mentioned is not convincing. The reviewer is not sure how down-speed calibration can help this program a lot because the benefits with down-speed can be only seen in an integrated vehicle among engine, transmission and axle. Furthermore, relying on driving turbo (Slide 16) to achieve 50% goal is optimistic, because this driven turbo is more like electric type rather that waste heat turbo-compound that pass the work directly to the engine crankshaft. The reviewer added that the developer should be aware that drawing the energy from the battery to charge the engine would reduce brake-specific fuel consumption (BSFC) as well, and that efforts relying on E-turbo would not be sustainable for a long period of time.

Reviewer 6:

The reviewer indicated that the project scope holds similar elements to the Cummins and Detroit Diesel projects. The reviewer would like to have seen more emphasis on waste heat recovery research. The reviewer expressed disappointment in the delays in the project, and suggested a review of results in relation to other similar successful work.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer stated that there were very impressive parasitic reductions through variety of approaches. VVA work was nice to see, different from others, and helps build to 55% BTE.

Reviewer 2:

The reviewer indicated that excellent progress was reported, and with more detailed data, rating could be improved to excellent or outstanding. Reported to be approaching 50% goal at 48.3% BTE actual. The reviewer reported that the engineering data provided is extremely limited and includes only a few highly diluted plots. Data showing work on diesel engine performance, and engine-out emission data and exhaust temperatures relative to baseline engine could improve rating. The reviewer added that the data provided only for dual fuel engine is not convincingly substantiated for the level of result reported and funding provided.

Reviewer 3:

The reviewer said nothing too different; however a bit more work on the dual fuel without too much is exciting.

Reviewer 4:

The reviewer stated that 48.3% is not too impressive even though the program has been paused for a while, mainly all of its competitors are making striking progress.

Reviewer 5:

The reviewer commented that Navistar did undergo a period to overcome critical company issues wherein the program was paused. After coming out of the pause period, the project team has made a sufficient amount of progress to demonstrate a 48.2% BTE engine through dynamometer tests. The reviewer added that the project team plans to achieve 50% BTE by using an additional driven turbo. The reactivity controlled compression ignition (RCCI) work conducted at ANL demonstrates 45% BTE through the use of a diesel plus gasoline/alcohol mix. While the gains are significant they do not hold promise to be a candidate technology to achieve 55% BTE.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer remarked that the project team was excellent using strong Tier 1 suppliers, national laboratories, and universities to meet goals.

Reviewer 2:
The reviewer said very solid, the ANL connection seems quite extensive.

Reviewer 3:
The reviewer stated that as shown in Slide 6, Navistar has worked with various part suppliers including Bosch, Mahle, Borg Warner, etc.. The Project team has exclusively worked with ANL in evaluating RCCI on an engine equipped with VVA.

Reviewer 4:
The reviewer commented that there was broad collaboration with reputable partners. The roles fit nicely into program, but progress from each is unknown. The reviewer added that some sacrifice due to pause is likely inevitable.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer noted that the driven turbo approach will be key. The reviewer would like to see 50 BTE without WHR, and characterized this as realistic. The dual fuel approach to 55% BTE is similar to others, but analyses seem to be developing.

Reviewer 2:
The reviewer thought that the approaches taken in ace060 and ace057 show a clear path to 55% or greater BTE without the added complexity or emissions issues associated with dual-fuel combustion. The reviewer would rather see this work redirected towards part-load low-temperature combustion (LTC) or taking further advantage of the VVA system via Miller cycle along with further WHR improvements to achieve 55% BTE.

Reviewer 3:
The reviewer said that there was good proposed future work following building block technologies. Focus should be on data driven approach and data sharing.

Reviewer 4:
The reviewer stated that even after considering the fact that Navistar has been through some rough times, one cannot overlook the fact that Navistar does not have a pathway to demonstrate a vehicle fuel efficiency improvement of 50%. Aerodynamic drag reduction, light-weighting, low rolling resistance tires, etc. as pursued by other teams are important factors towards achieving overall vehicle efficiency improvement, and they cannot be ignored. Also, the reviewer said that the technology mix identified by Navistar towards demonstrating 55% BTE engine is rather weak.

Reviewer 5:
The reviewer warned that completely relying on E-turbo in the future to achieve 50% efficiency is highly risky.

Reviewer 6:
The reviewer said the research plan lacks innovation.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer said that although the progress is behind their competitors due to pause period, all the work that has done so far would definitely support the overall DOE objectives of petroleum displacement

Reviewer 2:

The reviewer commented that the SuperTruck 50% BTE goal with near-term production technologies and 55% stretch goals will enable significant fuel savings due to the high fuel burn of Class 8 trucks in the medium and HD sector, which accounts for approximately 30% of all transport fuel burned annually.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer indicated that the high and sufficient level of funding requires high level of reporting responsibility.

Reviewer 2:

The reviewer stated that there is much work left, but seems well-funded.

Reviewer 3:

The reviewer reported that a total of $35 million out of the promised $39 million has already been allocated by DOE just to see the demonstration of a 48.2% efficient engine. Even looking at the individual technologies in the technology mix, besides driven turbo all others are more or less similar to the ones pursued by other teams. The reviewer is afraid that DOE is getting a miniscule return on investment (ROI) in this project.

Volvo SuperTruck - Powertrain Technologies for Efficiency Improvement: John Gibble (Volvo) - ace060

Presenter

John Gibble, Volvo.

Reviewer Sample Size

A total of eight reviewers evaluated this project.

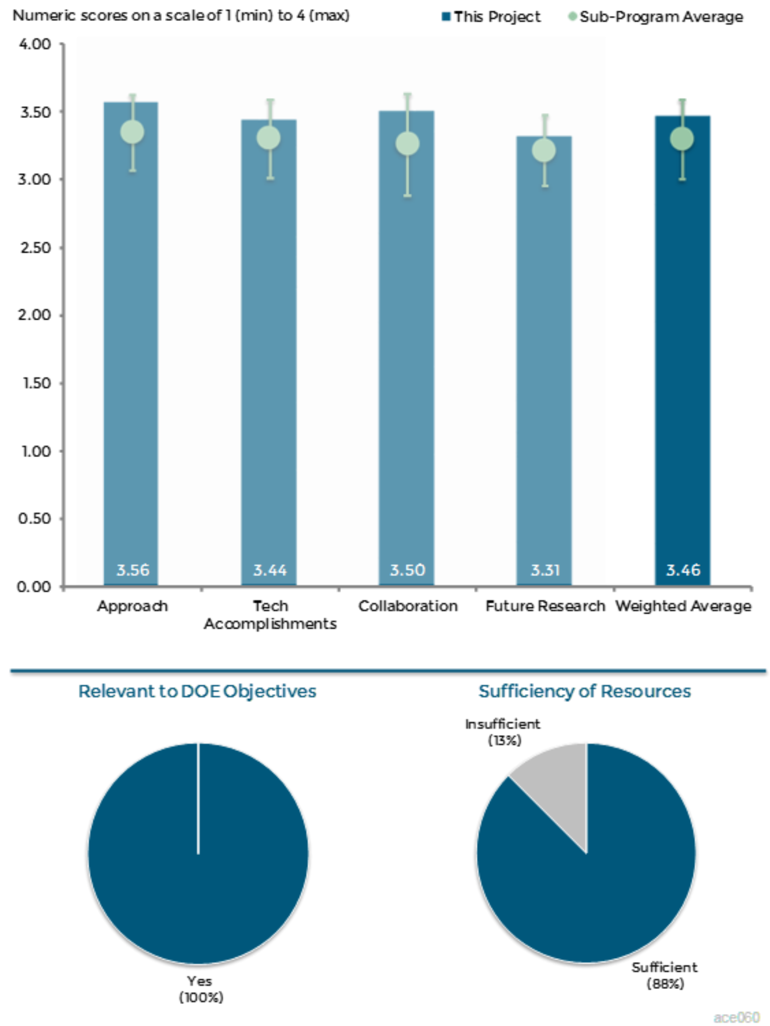

Figure 4-28 Volvo SuperTruck - Powertrain Technologies for Efficiency Improvement: John Gibble (Volvo) – Advanced Combustion Engines

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commented that as compared to all the awardees under the SuperTruck program, Volvo has identified a logical pathway that establishes technology development goals for 55% BTE engine, 50% freight efficiency vehicle improvement, and a 50% BTE engine. Moreover, each of these three stages feed into each other to identify a logical path. Additionally, the reviewer said that the barriers associated with each stage are adequately identified. This awardee deserves an extra credit in choosing a technology pathway that also accounts for customer requirements, and in being able to deliver a commercial product finally.

Reviewer 2:

The reviewer reported that Volvo achieved greater than 50% BTE without WHR. This is an outstanding accomplishment.

Reviewer 3:

The reviewer stated that the project had an excellent approach to meet SuperTruck 50% thermal efficiency truck-based goal with building blocks of WHR, aftertreatment, down-speeding, downsizing, air handling, pumping work, friction, combustion and current engine level demonstration at 50%. The project is a good pathway for 55% efficiency described is all diesel fuel approach. The reviewer added that a successful diesel-only approach is expected to have lower probability for success than bi-fuel or alternate fuel approaches according to industry experts so has raised some concerns. For excellent rating for 55% pathway and 50% vehicle level performance, detailed sharing of performance, FE, and emission data and assumptions should be provided as well as confirmation that down-speeding and downsizing can in fact perform in time to speed/time to torque as effectively as base comparison engine.

Reviewer 4:
The reviewer said the project had a good mix of technologies to achieve these aggressive goals. There is a logical balance of 50% and 55% engine approaches with good technology transfer and translation between both goal engines.

Reviewer 5:
The reviewer indicated that the project team is doing a good job of catching up on a lower budget.

Reviewer 6:
The reviewer remarked that the approach was outstanding and different to final goal of 55% BTE, starting there and going backwards to build up to final goal. Good start with modeling to guide work. The reviewer added that in regards to 48% BTE without WHR, it was excellent to incorporate durability testing into evaluation.

Reviewer 7:
The reviewer explained that this area could have been explained much better in the presentation, only a general sense of the approach for the various areas was mentioned, making it difficult to evaluate without details. The project conducted a lot of on-the-road testing of major components, which provides a high level of confidence that the final product will be robust. The reviewer added that the WHR expander was coupled to engine directly, which is a novel approach. It seemed that the difficulties associated with that were not mentioned. The reviewer also said a good use of simulation tools was able to make improvements during phase II.

Reviewer 8:
The reviewer commented that it is not clear what assumptions are used to achieve 56.2% goal, specifically using GT-Power. Simulations can provide anything one wants, but under what conditions. The reviewer added that if the entire work is based on simulations, the assumptions must be explained and exposed, this should be part of the program. Using proprietary as a way to avoid the questions and answers are not helpful.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:
The reviewer noted that the progress is good for the current stage of the program. There is still more work to do, but in particular, the 50% BTE goal engine has demonstrated excellent efficiency. Also, the reviewer said that advanced WHR hardware has been designed, built, and demonstrated. The 55% BTE engine concept is in simulation stage but showing predictions to meet the goal (in large part due to extra expansion).

Reviewer 2:
The reviewer said that the second engine build is impressive. New WHR expander very impressive and unique. Good transfer into production and use of developed technology. The reviewer added that there was an impressive modeling and plan to 55% BTE. Head room with single fuel modeling.

Reviewer 3:
The reviewer liked the in-house WHR development. This technology is going to succeed with so many players. The reviewer also likes the rapid propagation of the technology to production. The reviewer was not happy with just modeling to validate the integration.

Reviewer 4:
The reviewer reported that simulations have been completed per the plan. Some down-select of engine design was referred to, but the process for doing this was not given. The reviewer said this would seem to be a major accomplishment.

Reviewer 5:

The reviewer commented that the vehicle at 45% and engine dyno components meet the 50% BTE goal. Verbally described emissions (NO_x, PM) at much reduced engine-out levels with aftertreatment challenge lower exhaust temperatures. The reviewer added that for outstanding results, pathway for 55% efficiency outlined (Parasitic Reduction, Waste Heat Recovery, improved Gas Exchange, Heat Loss Reductions, Combustion Improvements, Over-Expansion) should be detailed to vet assumptions in models and the potential performance/emission impacts. There was excellent activity to internally design a downsized WHR device in house at Volvo, outstanding when data is made available.

Reviewer 6:

The reviewer reported that achieving the 50% goal with all key enabling component is encouraging; however, it is not clear how the simulation can show 56.2% without any experimental tests to back it up. Simulation can be garbage in and garbage out under any unrealistic assumptions. The reviewer added that the details of the assumptions shall be released. The work with new generation of WHR is encouraging, specifically on the turbine expander.

Reviewer 7:

The reviewer stated that from the presentation it is not clear whether funding was partially curtailed, or poor execution by the awardee but the progress made is somewhat less as compared to other awardees. The reviewer's assessment towards the three DOE goals is as follows; 50% BTE engine demo, Awardee has demonstrated a 48% BTE engine. Currently working on WHR system optimization that can potentially enhance future engine BTE. 50% improvement in freight efficiency; Not yet demonstrated. The schedule chosen identifies this deliverable at the end of fiscal year (FY) 2016. Regarding the 55% BTE engine pathway, the reviewer explained that the awardee has identified a path that is not too different from other awardees through a modeling effort with partner universities. The reviewer added that notably two achievements differentiate the present effort from that of other awardees, a five-stage axial expander for WHR, and inclusion of expanded expansion cycles towards achieving 55% BTE.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer commented that there was very impressive collaboration, even with the Swedish government. Nice to see the customer as part of the collaboration. The reviewer added that there was modeling, lighting, and components.

Reviewer 2:

The reviewer said that coordinating all those partners is a solid accomplishment.

Reviewer 3:

The reviewer reported that Volvo lists 11 partners on Slide 19, which also includes 4 universities.

Reviewer 4:

The reviewer noted that the large multinational truck company Volvo/Mack is leveraging well internal inter-divisional resources and component/system suppliers for 50% engine based activity and top list of universities for 55% BTE and modeling/testing including University of Michigan, Penn State, and Drexel University. The team also has fuels and lubes support through a major international fuel supplier.

Reviewer 5:

The reviewer indicated that this project does not have very many partners on the engine efficiency portion. Most partners mentioned were related to vehicle/trailer or full truck demonstration portion of the project, which is not what this reviewer is evaluating. The reviewer added that additional collaborators on the engine efficiency stretch 55% goal could benefit the project.

Reviewer 6:

The reviewer said there was a nice team of collaborators. It would be better if more definition of the role of Penn State University was given. The reviewer said it is not clear how the collaboration on simulation is occurring; so, for next AMR, the reviewer suggested a slide focused on explaining the roles and contributions and collaborations related to Penn State University. Numerous supplier involvement is excellent.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that 55% BTE single fuel approach is excellent. There seems to be room for error. The reviewer added that the project team had an evolutionary approach. The approach seems similar to others, but like to see less emphasis on WHR.

Reviewer 2:

The reviewer noted that the remaining proposed research is to execute project deliverables with an excellent building block plan. It would be outstanding to commit to some of the stretch goal performance testing for 55% BTE.

Reviewer 3:

The reviewer reported that the future research plans were good; however, there was not a lot of detail on the 55% BTE engine hardware plans given.

Reviewer 4:

The reviewer stated that the future work on implementation of new WHR is technically solid, which should help the program to achieve the goal. It is not clear what kinds of tests that are used to support the simulations are developed.

Reviewer 5:

The reviewer said that the future research proposed looks good.

Reviewer 6:

The reviewer asked the project team to please describe “over-expansion” in greater detail.

Reviewer 7:

The reviewer commented that the project team really needs to show the integrated hardware. This sometimes sounds like a part development project.

Reviewer 8:

The reviewer indicated that if Volvo were to stick to the proposed schedule, one’s assessment is that they will be able to deliver a 50% BTE engine; however, the team is likely to fall short in meeting the other two goals, for example, demonstrating a greater than 50% increase in freight efficiency and in identifying a viable pathway towards 55% BTE engine.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer said that the Class 8 trucks represent the largest fuel consumer in commercial vehicles and commercial vehicles are the second largest consumer of petroleum after passenger cars. Customers of the vehicles also value fuel efficiency as a top driver for purchase. The reviewer added that the technologies for fuel savings implemented will therefore save more fuel per vehicle than any other, and the pull from the market is the strongest in the commercial sector.

Reviewer 2:

The reviewer stated that all of the technologies pursued in the project will decrease petroleum consumption specifically in the HD sector. Furthermore, the technologies are wide ranging and will enable economic benefits to many industry areas from original equipment manufacturers (OEMs) to suppliers. The reviewer added that importantly, the benefits are directly applicable to the transport of goods in the United States; therefore, economic benefits will extend to everyone.

Reviewer 3:

The reviewer indicated that Class 8 improved fuel efficiency will be a major reduction in petroleum consumption.

Reviewer 4:

The reviewer noted that with many advanced technologies developed under this program, which have potential to be used in production, this project support the overall DOE objectives of petroleum displacement.

Reviewer 5:

The reviewer said yes.

Reviewer 6:

The reviewer commented that the pathway for 50% efficiency was proposed.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said that it is amazing that Volvo can achieve the same goals as others while the funding is only half of their competitors.

Reviewer 2:

The reviewer stated that it was very impressive to see the progress at reduced money.

Reviewer 3:

The reviewer reported that although the project had a lower funding total than other SuperTruck projects, the work level and progress are geared relevant to the funding.

Reviewer 4:

The reviewer remarked that Volvo has agreed to meet the metrics spelled out for all SuperTruck teams at roughly half the budget.

Reviewer 5:

The reviewer commented that this project seems to be funded at a much lower level than the others.

Reviewer 6:

The reviewer said the project team is making decent progress.

ATP-LD; Cummins Next-Generation Tier 2 Bin 2 Diesel Engine: Michael Ruth (Cummins, Inc.) - ace061

Presenter

Michael Ruth, Cummins, Inc.

Reviewer Sample Size

A total of six reviewers evaluated this project.

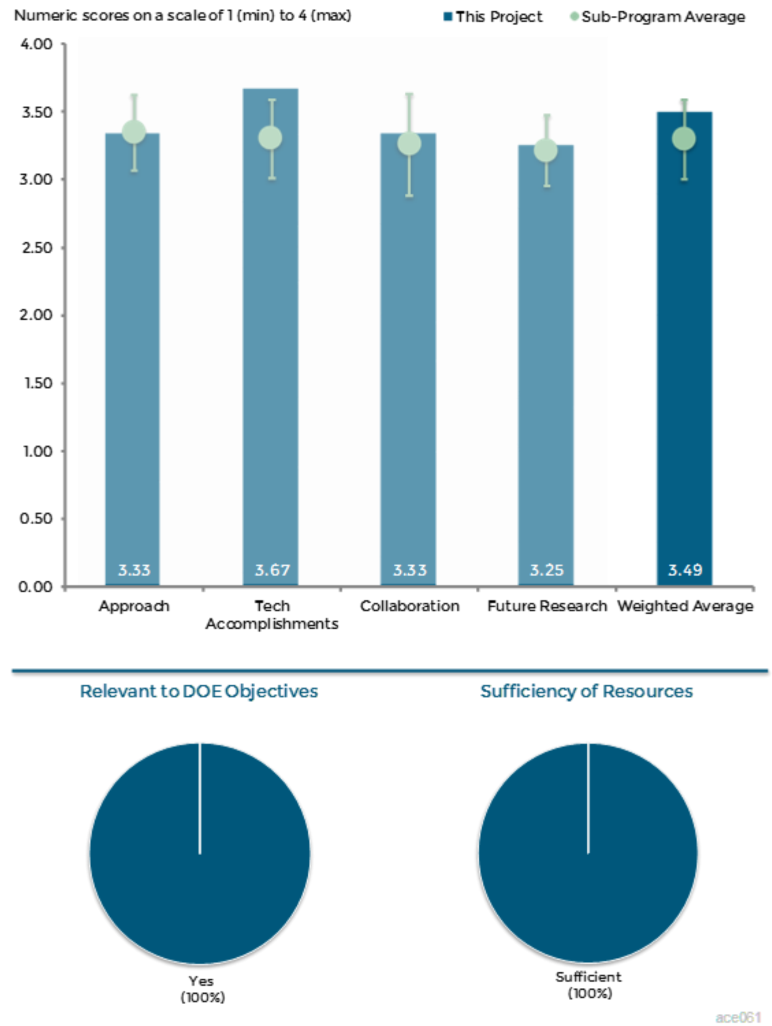

Figure 4-29 ATP-LD; Cummins Next-Generation Tier 2 Bin 2 Diesel Engine: Michael Ruth (Cummins, Inc.) – Advanced Combustion Engines

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer noted that this was a tremendous achievement. Having a light-duty (LD) diesel truck capable of Tier 2 Bin 2/Tier 3 Bin 30 emissions would have been impressive on its own merits. The reviewer added that doing so while achieving better FE than comparable current Tier 2 Bin 5 LD diesel trucks makes this project even more impressive.

Reviewer 2:

The reviewer said that the project team had a very sound and comprehensive approach.

Reviewer 3:

The reviewer stated that the approach by Cummins in the engine development to meet Tier 2 Bin 2 standards is highly questionable as the inline four engine development targets do not match the power of the baseline V8. There is a wide gap on the torque and power capabilities from both engines. The reviewer added that on the other hand, the program leverages a strong approach when incorporating an emission control strategy with minimum fuel penalty.

Reviewer 4:

The reviewer stated that the project team had an excellent approach to meet target to achieve 40% FE improvement over gasoline V8 half-ton pickup truck and meet Tier 2 Bin 2 emission requirements by replacing a gasoline engine with smaller diesel and emission control system (ECS) without a weight penalty. Excellent down-sized engine concept has high power density. The reviewer added that the approach could be improved to outstanding by demonstrating diesel which matches base target V8 engine power/acceleration, noise/vibration and by implementing a more production- proven mainstream aftertreatment such as NO_x absorber. Aspects of Cold Start Concept (CSC™) catalyst for cold start have not been implemented due to durability/cost/functionality. The reviewer also said that NO_x and HC mitigation (traps) have not been durably used in production and the NH_3 gas system applied for immediate reductant delivery is a relatively long-term production possibility as significant industry and supplier alignment /standardization would be required.

Reviewer 5:

The reviewer said this is basically an engine/aftertreatment integrate. It can show what can be accomplished with good integration and new aftertreatment technology.

Reviewer 6:

The reviewer stated that there was a good approach to matching or exceeding the torque of base engine and not the power, but this did raise a question of whether the comparison was fair between the 2.8L diesel and much larger V-8 baseline. The reviewer recommended that, even though the project is over, to prove that the overall utility and drivability of the vehicle is maintained by equal torque instead of equal power. Use of novel SCR system added technical value but detracted from perspective of near-term commercialization.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer liked what the project team have accomplished with the aftertreatment. The reviewer said that light-duty diesels can be done in the United States. The cost/weight comparison was well done.

Reviewer 2:

The reviewer commented that this is truly an outstanding showcase of LD diesel combustion control and exhaust emissions control.

Reviewer 3:

The reviewer stated that the program successfully demonstrated Tier 2 Bin 2 emissions compliance on two prototype vehicles. Emissions and fuel consumption are presented on the U.S. Environmental Protection Agency () 75 test, meeting the required standard. The reviewer added that the current presentation includes a comprehensive review of the aftertreatment. The authors also indicate the team attained the weight neutral goal. The reviewer said that the program includes a gaseous NH_3 for NO_x reduction. Discussion on this highlighted that a better choice would have been aqueous NH_3, especially in the incorporation of the cold start concept (dCSC™) element from Johnson Matthey. The program could have been clearer on the engine description such as the capability of the valve train, EGR high and low pressure loops.

Reviewer 4:

The reviewer remarked that the project achieved or exceeded goals in FE and also reached Tier 2/Bin2 emissions levels. The project also achieved weight parity with base engine.

Reviewer 5:

The reviewer reported that the project exceeded the efficiency improvement goals.

Reviewer 6:

The reviewer stated that the project had excellent results meeting FE and emissions. The project could be outstanding with downsized engine meeting or exceeding base engine power and torque; noise, vibration, and harshness (NVH); and a look at value analysis compared to competitive gasoline engine. The reviewer added that a value analysis would include at least a sense check for techno-economic/market assessment for value of FE improvement relative to acceleration and aftertreatment cost penalties. (The reviewer assumed the CSC concept is a higher cost than a three-way catalyst and that acceleration of a lower-powered diesel engine vehicle is slower than that of V8 gasoline.)

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that clearly this is a close industry collaboration. The reviewer is not really sure about the Purdue University connection, but the collaboration has been exceedingly successful. So, in this case it is not the number, but the effectiveness.

Reviewer 2:

The reviewer commented that collaborators have clear and critical roles and that there were no extraneous collaborators for appearance-sake.

Reviewer 3:

The reviewer said that the aftertreatment partners in this project appeared to be vital to the outcome and were good match. The coordination by Cummins was excellent.

Reviewer 4:

The reviewer noted that the team includes critical partners in the aftertreatment (Johnson Matthey), vehicle (Nissan), and academia (Purdue University). The presentation could have provided more detailed information on their contribution.

Reviewer 5:

The reviewer reported that the partnership with Johnson Matthey appears to have been very successful. Integrating low-temperature NO_x adsorption SCRF® was key to achieving exhaust emissions targets.

Reviewer 6:

The reviewer indicated that excellent collaboration including Purdue University, which worked to evaluate valve train timing aspects, and develop aftertreatment technology with Johnson Matthey. Stronger OEM vehicle coordination for a full suite of vehicle metrics such as time to acceleration/torque, NVH and other drivability metrics could make project collaboration outstanding.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer commented that the project team is ahead of the timeline. So the future plans are all gravy.

Reviewer 2:

The reviewer reported that this question was not applicable and that the project is completed. However, this project is a good example of the DOE making good investment choices in the research it is funding. The reviewer added that projects like this, which develop technology for the benefit of consumers, should be continued.

Reviewer 3:

The reviewer stated that the project is winding down to completion in 2015. Excellent project and FOA pushes envelope for development of practical FE and emissions technology with a technology agnostic approach. The reviewer added that future FOAs of this type are excellent to speed the tech to market timing of near-term FE technologies and to move the ball for longer term approaches. To be outstanding, future FOAs should include vehicle level or engine level metrics such as power density, acceleration, time to torque, and some indication of production technology readiness for building block technologies (1-3 year, 4-7 year, 10 year potential) and what barriers need to be removed to move up. The reviewer commented that high pot building blocks and barriers may drive other FOAs.

Reviewer 4:

Reviewer 5:

The reviewer stated that the project ended. Press announcements are out on V8 Cummins in Nissan. The reviewer commented that there would have been value-added to say whether findings from the ATLAS project were used in the V8 commercial engine.

Reviewer 6:

The reviewer said that the Project was completed.

Reviewer 7:

The reviewer said that the program is complete.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer said that this project supported the development of a considerably more efficient engine. Although diesel fuel is higher carbon, overall GHG reduction is still realizable. The reviewer repeated that the impact on DOE's mission would be more obvious if this engine were going to commercial use or that its technology were being adapted to a commercial product.

Reviewer 2:

The reviewer commented LD diesels at a gasoline powertrain price. It will make major inroads.

Reviewer 3:

The reviewer remarked that as proposed, an across the board fleet FE improvement in light trucks and SUVs of 40% could reduce U.S. oil consumption by 1.5 million barrels /day.

Reviewer 4:

The reviewer noted that this project contributes to the DOE mission to reduce petroleum consumption.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said well-funded, partner match, well delivered.

Advanced Gasoline Turbocharged Direct Injection (GTDI) Engine Development: Corey Weaver (Ford Motor Company) - ace065

Presenter

Corey Weaver, Ford Motor Company.

Reviewer Sample Size

A total of five reviewers evaluated this project.

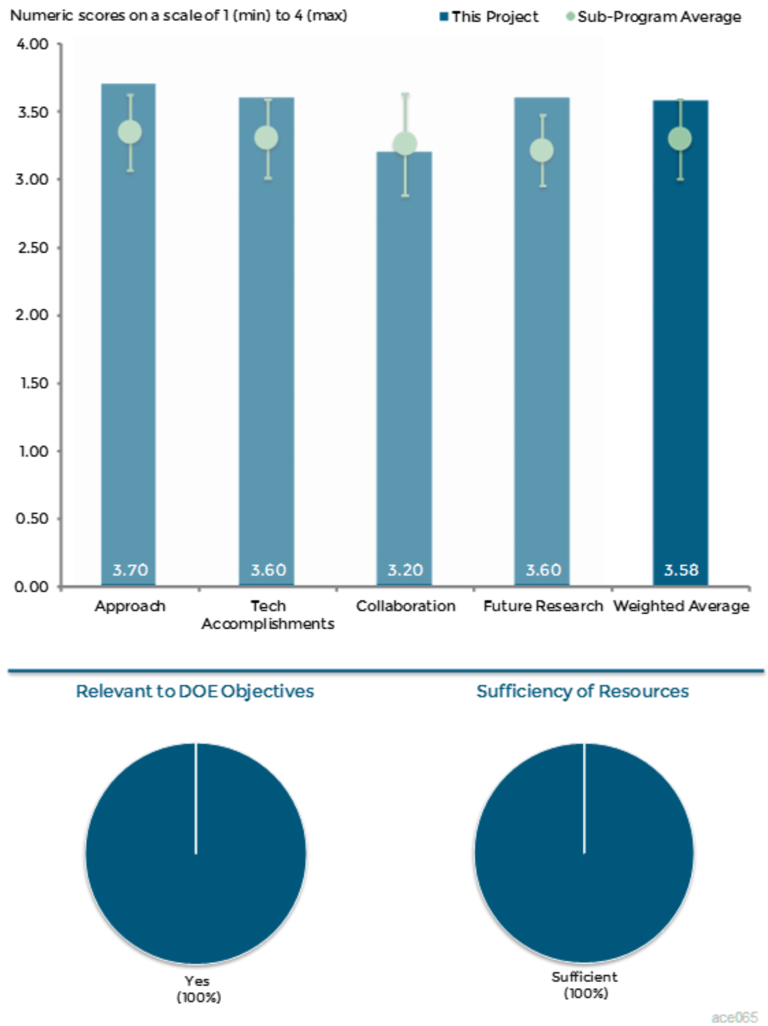

Figure 4-30 Advanced Gasoline Turbocharged Direct Injection (GTDI) Engine Development: Corey Weaver (Ford Motor Company) – Advanced Combustion Engines

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that it was a tremendous achievement to obtain a 25% corporate average fuel economy (CAFE) improvement while maintaining stoichiometric 3-way catalytic emissions control and Tier 3 Bin 30 emissions.

Reviewer 2:

The reviewer remarked that the high-compression, dilute combustion strategy is an excellent approach to improving efficiency. It was very well-planned and well-conceived. The reviewer added that this project is nearing its conclusion and has already achieved most of its targets, so the approach was clearly effective.

Reviewer 3:

The reviewer said outstanding and clearly communicated methodology. The project team used engine and vehicle technology elements with high potential for tech to market. The reviewer added that the project has a process following state-of-art vehicle OEM product development cycle from modeling and simulation, product design, on dyno testing with simulation loops, value analysis, vehicle integration and full drivability emissions assessment. Real-world vehicle level metrics clearly defined for fuel economy, emissions, as well as drivability power/acceleration and NVH.

Reviewer 4:

The reviewer noted that this project is a nice example of what it takes to put some advanced engine efficiency technologies through an OEM design cycle to get them close to production. The approach is not overly aggressive compared to other DOE-funded projects, but perhaps this gives the technology a better chance to go into production. The reviewer had some difficulty differentiating this project from the technology already included in the production EcoBoost engine from Ford. From that perspective, it would have been nice to use a production EcoBoost as the baseline engine for this project; however, the use of external cooled EGR is noteworthy as a technology that was included for efficiency.

Reviewer 5:

The reviewer commented that the Ford team has not achieved the performance targets by a combination of engine downsizing, and a host of other technologies while staying with the traditional boosted stoichiometric engine with high EGR and three-way catalyst. The other technologies listed in the AMR presentation are all advanced without giving all the details. The reviewer added that the fact that the project team has developed an engine with research octane number (RON) 98 as the fuel specification allows the team to claim higher efficiencies; however, this is not very practical.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer reported that the project team set out what it intended to do. From the number of engines, vehicles, and operating hours involved, it is obvious that the robustness of this technology was a central consideration. The reviewer added that this will allow Ford to make production-relevant decisions about the technologies included, which supports DOE's goal of accelerating high efficiency technologies into the marketplace. The project was aiming for definitive answers about the technology rather than just check-the-box measures of progress.

Reviewer 2:

The reviewer said outstanding delivery of committed DOE and other vehicle level metrics. The project goals for FE and emissions exceeded DOE goals. The reviewer added that the vehicle meets industry required production acceleration drivability metrics and demonstrated in prototype vehicles with packaging that is near term production plausible. Downsized engine design meets or exceeds time to torque (acceleration) targets established by baseline engine and packages inside production vehicle platform. Also, the reviewer said that high granularity of data demonstrates significant effort following established product development for production pathways. Fully integrated potentially near term production vehicle hardware package delivered that exceeds DOE FE and emission targets augmented by solid effort to move the ball toward future FE gains through R&D on stretch technologies such as lean burn injection, combustion, and advanced ignition hardware and strategies as well as advanced aftertreatment, including passive NH_3 generation for SCR.

Reviewer 3:

The reviewer indicated that the engine dyno results are quite impressive. The project team has done a lot of very good work. The reviewer added that there appears to be a very good chance of meeting the final vehicle efficiency targets at the conclusion of the project.

Reviewer 4:

The reviewer commented that all goals appear to have been met over the course of this project. The reviewer thought it would have been helpful to show results on both 95 RON fuel as well as the 98 RON fuel used because 95 RON is actually available in the United States, even if this meant the loss of several percent relative to the FE target.

Reviewer 5:

The reviewer stated that from the presentation made at AMR one gathers that Ford has achieved, and in some cases surpassed, the DOE goals; however, it remains to be seen as to how many of the technologies developed here will transition to the market.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer noted that there was excellent collaboration with supplier companies as well as Michigan Technological University to deliver stretch goals. Possible inclusion of an advanced aftertreatment supplier to move the ball further on stretch technologies would make this outstanding.

Reviewer 2:
The reviewer stated that Ford has collaborated with Michigan Technical University to evaluate various ignition system variants. Many of the findings are perceived to have transitioned into the final engine developed.

Reviewer 3:
The reviewer commented that there is only one collaboration partner, which is a university subcontractor that appears to have a relatively minor role in the project. It is not surprising that an OEM would prefer to keep most of an engine development program in-house, however, and the reviewer would consider this satisfactory.

Reviewer 4:
The reviewer stated that there is only one partner on this project, so there are not many collaborations; however, as this is a project led by an OEM with a vehicle demonstration, the number of outside collaborations does not need to be large to achieve the project goals.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer stated that the Ford team has exhibited exceptional project planning and execution.

Reviewer 2:
The reviewer remarked that this was an excellent FOA and the results with the project wrapping up in 2015. Ford's approach on this project, the level of data, and the results for this FOA is are a good case study. The reviewer added that the approach applies building block technologies, vetted with value analysis, and applied through a clear pathway toward plausible integrated vehicle level approach to meet FE target that have potential for production pathways near-term as main pathway, while also moving the ball on other promising technologies that are possibilities for future fuel efficiency improvement. FOA technology agnostic approach is excellent, and typically used industry vehicle metrics shown in Ford’s data, such as time to acceleration, noise vibration, and idle quality, is outstanding.

Reviewer 3:
The reviewer said that the project is reaching its conclusion, and the path to completing the remainder of the work is straightforward.

Reviewer 4:
The reviewer reported that the chassis dynamometer testing appears to be the sole remaining task.

Reviewer 5:
The reviewer indicated that this project is wrapping up, so future work is not really applicable in the context of this project. The reviewer hopes to see this technology in the marketplace.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer indicated that the Ford team has successfully developed a highly efficient engine, integrated into a midsize sedan and finally evaluated the performance of the vehicle to demonstrate, achieving DOE goals. For example, a 25% reduction in fuel consumption while meeting emissions standards.

Reviewer 2:

The reviewer commented that the development of production plausible near-term vehicle technologies integrated on a production vehicle to achieve over 25% FE improvement on midsize sedan has high potential to significantly reduce vehicle petroleum use.

Reviewer 3:

The reviewer stated that efficiency improvements of the scale demonstrated in this project will have a significant impact on vehicle fuel use once the technology reaches the market. Some of the efficiency gains would be contingent on availability of high-octane fuel, for example, renewable super premium.

Reviewer 4:

The reviewer reported that this is highly relevant as it is bringing high EGR dilution technology closer to production, providing a very real efficiency benefit. While the baseline engine could have been a smaller displacement and the technology targets could have been more aggressive, the technology developed will inform production decisions in a shorter-term way than many DOE-funded projects.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer indicated that while this project appears to be coming to an end, it was able to achieve the 25% FE targets for advanced dilute combustion without going into exotic combustion/controls (GCI, lean burn, etc.) and thus had a far simpler task achieving Tier 3/Level III emissions. This was a very successful approach. The reviewer would like to see additional developmental work on this platform to see its capabilities on fuels more representative of current U.S. gasolines, for example, 91 RON and 95 RON.

Reviewer 2:

The reviewer noted that the large project budget has been judiciously used and effectively matched.

Reviewer 3:

The reviewer stated that the project appeared to be on-schedule after a delay early in the project, and not in need of additional resources.

Advancements in Fuel Spray and Combustion Modeling with High Performance Computing Resources: Sibendu Som (Argonne National Laboratory) - ace075

Presenter

Sibendu Som, Argonne National Laboratory.

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

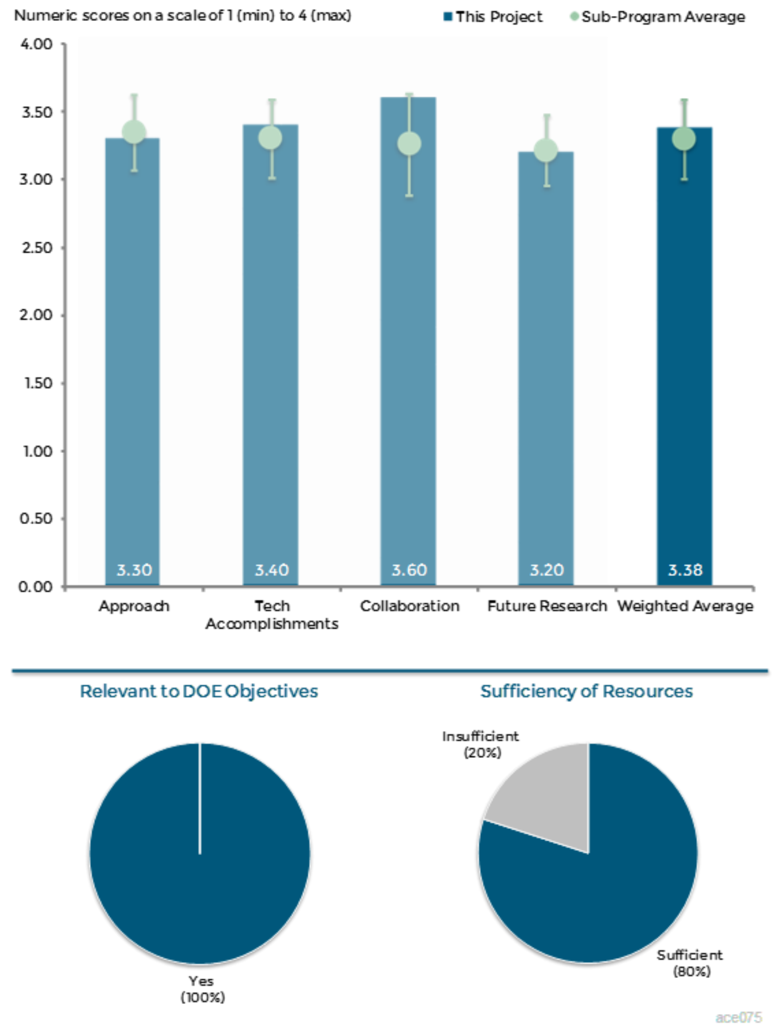

Figure 4-31 Advancements in Fuel Spray and Combustion Modeling with High Performance Computing Resources: Sibendu Som (Argonne National Laboratory) – Advanced Combustion Engines

Reviewer 1:

The reviewer stated that the approach of developing models and comparing results to production injectors is very good. Results of approaches used in this work appear to have convinced an equipment/engine manufacturer to use these techniques.

Reviewer 2:

The reviewer reported that undoubtedly this project is one of the leading efforts on detailed spray modeling and injector flow modeling, and coupling those two processes. Being able to simulate needle wobble and probabilistic nature of shot to shot variation due to that is novel. The reviewer added that for the supplier to be able to incorporate such simulation in their design improvement is encouraging. There was some attempt to explain the workflow but, in the future, dedicating a slide or two in collaboration with the supplier to map out the process of tangible impact on hardware design would be interesting if presented.

Reviewer 3:

The reviewer commented that the work provides a good approach seeking to minimize manual tuning of models to experimental data, promoting more predictive simulations with higher fidelity models. The work focuses on detailed chemistry combustion models, finer mesh for grid-convergence, high-fidelity large eddy simulation (LES) turbulence models, and two-phase physics-based fuel spray and nozzle-flow models. This is combined with high-performance computing facilities.

Reviewer 4:

The reviewer said that this is an excellent project with an excellent approach including attempts to validate key portions of the computational framework. One area where the approach might be improved would be to present more realistic impacts of nozzle back pressure on wobble and cavitation. The reviewer added that it is recognized that the experimental facility at the Advanced Photon Source might have an operational limit, but this is an important topic that needs further investigation as relevant to direct injection (DI) diesel engines.

Reviewer 5:

The reviewer was not sure if high performance computing can really have any impact on reducing petroleum usage in the near-term horizon. Only sample demonstration calculations each of which takes 3-4 weeks to complete and cost on the order of a million dollars can be done. The reviewer added that it cannot be considered as a tool today to design tomorrow's engines. Maybe the engines of the day after tomorrow.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer remarked that this project consistently shows annual progress. Improvements in the ability to do high-fidelity models with high resolution, detailed chemistry, two-phase injection modeling with turbulence is definitely commendable. The reviewer added that the challenge is computing time even with super computers. The reviewer asked how do suppliers' engineering teams incorporate these methodologies. Also, a comparison of good calibrated low-fidelity models with high fidelity models and validation data would provide some insight into how much of this effort is necessary.

Reviewer 2:

The reviewer stated that the PI and team have made outstanding progress in the last year addressing wobble effects and in integrating injector nozzle boundary conditions onto the chemically reactive flow calculations.

Reviewer 3:

The reviewer stated that the significant accomplishments were made, which include: first-ever simulations of a production injector with full needle dynamics (with wobble), which showed that there is significant shot-to-shot differences in wobble, but does not affect global mass flow rates, surprisingly cavitation can occur at low lifts even when it does not occur at high lifts; demonstrated high-fidelity LES approach to capture dribbled mass from a single hole injector.

Reviewer 4:

The reviewer commented that progress on calculations with the LES model, dribble, etc. are commendable; however, more gasoline sprays should be modelled.

Reviewer 5:

The reviewer indicated that the work is technically sound. It covers a very comprehensive sub-model development. Overall the activities are focused. The reviewer added that the work on injector simulation with full needle dynamics is very descriptive. The work provides information of the injection event at low needle lifts where variability is more pronounced. The reviewer also stated that the wobble discussion was very informative. On Slide 8 there is some details on the needle motion. The authors may want to provide a fuller account in order to appreciate the nature of the phenomena described here. For example, the reviewer inquired about the following: the full lift of the needle; the diametrical clearances and tolerance in the injector; and what is used in the model. Similarly, the authors may indicate what the minimum dribble target is. The reviewer additionally said that the team has begun to work on optimized reduced mechanisms for a diesel surrogate. This is being applied to LES modeling. Initial results show increased resolution that manifests multiple ignition sources. The reviewer said that the authors also showed how LES was able to capture dribble mass. These efforts have not been applied to engine simulations yet. The reviewer recommended applying them to selective engine cases to assess its significance in the context of emissions and FE. It is unclear now what such massive effort in the computational area will yield in real life operation.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer said that collaboration with other labs, the Engine Combustion Network (ECN), universities, suppliers, and an OEM is excellent. If this research and fundamental understanding can be considered pre-competitive, which the reviewer thought it was, then why not bring more or all of the fuel injector suppliers to the cooperative research & development agreement (CRADA) tables for improving the success of these methodologies in fundamental understanding and hardware design improvements. The reviewer added that it also appears that a commercial CFD vendor working with high end researchers is a good way to develop and disseminate this development to a wider community.

Reviewer 2:
The reviewer said very good team.

Reviewer 3:
The reviewer commented that there was very close collaboration with two equipment/engine manufacturers and with a simulation development company, as well as with two universities and several other national laboratories.

Reviewer 4:
The reviewer reported that this project includes collaboration with various industry partners, some universities, and another government agency.

Reviewer 5:
The reviewer stated that more collaboration can be pursued with suppliers of gasoline fuel injectors for LD automotive applications.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer remarked that the future work is certainly well planned. This project makes step improvements every year. The reviewer had no doubts about the success towards FY 2015 milestones.

Reviewer 2:
The reviewer reported that the U.S. automotive LD fleet consists of 96-97% gasoline engines. The portfolio of work should be adjusted so more gasoline sprays and combustion are being modeled if one hopes to impact petroleum consumption of the LD fleet.

Reviewer 3:
The reviewer reported that planned work should continue progress made and move further toward meeting program objectives. Good to see more work on gasoline.

Reviewer 4:
The reviewer stated that the proposed future research was clearly indicated. This includes one way coupling: transitioning to Lagrangian parcels at the nozzle exit, and 2-way coupling; and transitioning to Lagrangian parcels downstream of the nozzle exit. The reviewer indicated that the authors are planning to report on the influence of conicity and hydro-grinding on combustion and emissions behavior. The work with extend gasoline injectors. The project team will continue to improve scalability of engine codes and better and more representative chemical kinetic models. The reviewer wished to emphasize the importance of evaluating the simulation work in real engine applications to demonstrate the applicability and predictability of the models.

Reviewer 5:

The reviewer commented that it would be helpful if future work also included further exploration of nozzle back pressure effects on cavitation and wobble along with further validation of the dodecane mechanism at lower bulk temperatures and various injection pressures. Also, the reviewer asked how this overall effort compares with LES work at Sandia National Laboratories (SNL). The reviewer also asked is there overlap or duplication. This is not clear.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer noted that the project provides fundamental physical understanding of injector behavior and sprays crucial for ICE efficiency.

Reviewer 2:

The reviewer commented that this project should eventually provide engine designers a tool to aid in the development of next generation low emission and high efficiency engines.

Reviewer 3:

The reviewer stated that development of more accurate fuel spray and combustion models coupled with high performance computing will enhance the capability to more quickly design and commercialize advanced combustion engines will reduce fuel consumption and thus reduce amount of petroleum used.

Reviewer 4:

The reviewer reported that the injection characterization work is necessary for improving combustion modeling. This particular project is tied to other current programs. The reviewer added that any progress made here will be applicable across a wide horizon.

Reviewer 5:

The reviewer said that high-performance computing is a long-term play. It is out of the reach of the automotive industry presently.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that the project could benefit from additional resources to conduct experimental investigations of injectors at more realistic nozzle back pressures and also further validate the dodecane model at wider range boundary conditions.

Improved Solvers for Advanced Engine Combustion Simulation: Matthew McNenly (Lawrence Livermore National Laboratory) - ace076

Presenter

Matthew McNenly, Lawrence Livermore National Laboratory.

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

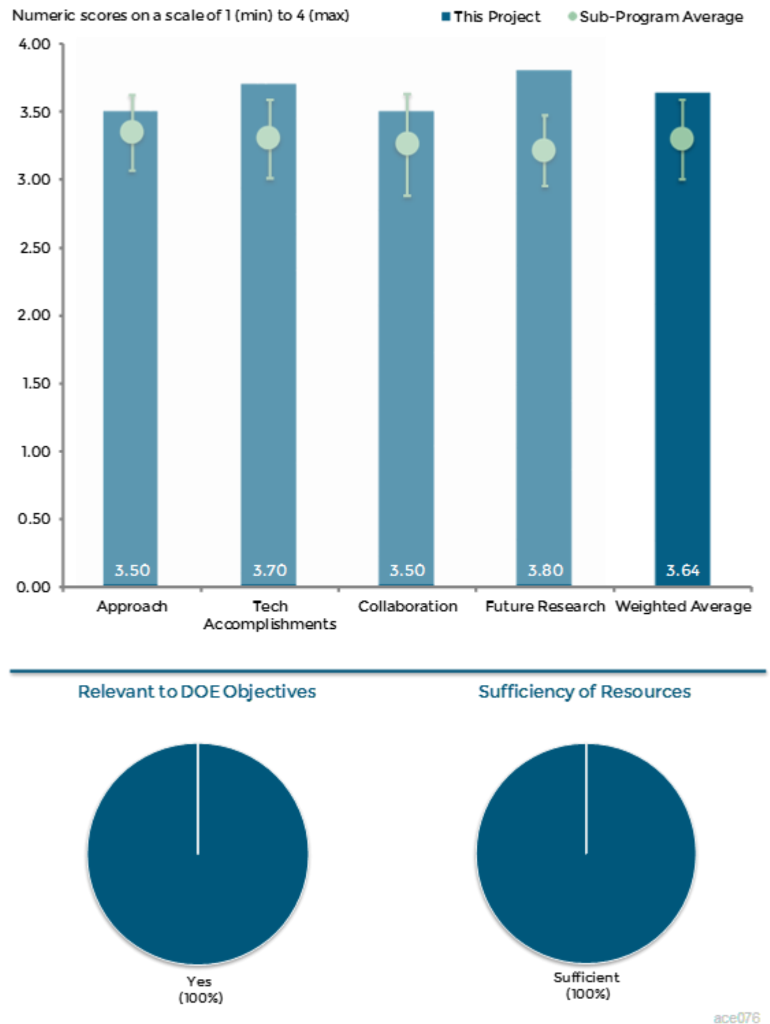

Figure 4-32 Improved Solvers for Advanced Engine Combustion Simulation: Matthew McNenly (Lawrence Livermore National Laboratory) – Advanced Combustion Engines

Reviewer 1:

The reviewer remarked that this is an exceptional program that addresses a real need; faster and more accurate chemistry calculations for multidimensional engine simulations. The bottom-up approach of attacking the computational approaches for these calculations (versus reducing mechanisms, etc.) is sound and the gains are substantial.

Reviewer 2:

The reviewer reported that the speedup work for chemistry solvers is critical; the approach to investigating how to implement the speedup for a wide range of use cases is valuable. This project is an enabler for the closer-to-the-metal projects as it is still in the development phase and not yet distributed to end-users.

Reviewer 3:

The reviewer said the project is creating faster, more accurate combustion solvers.

Reviewer 4:

The reviewer stated that this project concerns developing a capability for detailed in-cylinder predictions of engine performance, a goal shared by a number of project teams. The PI notes the lack of basic knowledge of engine combustion regimes, modeling capabilities and means to control engine performance. In response, the PI has formed a team of several industrials, national laboratories and universities to address this problem. The reviewer added that the need for a predictive simulation is of course important. There are a number of groups in academia and national laboratories pursuing the same goals. Interestingly, the PI himself seems to be pursuing similar goals in another project (ace012 with almost the same group of PIs; and a few slides seemed to be the same for the two presentations) that is evidently dealing more with combustion chemistry. The broad objectives of this project are to speed up the simulation process by developing faster predictive engine models and to use detailed chemistry in the simulations. Also, the reviewer said that this project should be better differentiated from ace012, as both have the same PIs, similar objectives and funding levels that total about $1 million ($0.5 million for each). The reviewer asked why this project could not be folded into ace012 (or vice versa). The reviewer added that the choice of fuel systems should be clarified. The reviewer asked why a nine-component surrogate (AVFL18) is selected. The rationale here is not clear.

Reviewer 5:

The reviewer suggested that the project team may want to explicitly state the differences between this project and Russel Whiteside's project (ace012).

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer said that by all indications there was a substantial improvement in performance.

Reviewer 2:

The reviewer stated that the demonstrated speedups are quite good, and the findings of problems in the thermo property fits are highly valuable in recognizing challenges with running simulations. Uncovering further limitations in high speed/high fidelity computations is of value too.

Reviewer 3:

The reviewer noted that the accomplishments and progress have been good, but the team is challenged to move into other aspects of the multidimensional engine simulation problem to advance all of the elements to make the entire engine simulation process faster.

Reviewer 4:

The reviewer indicated that the idea of using a kinetic scheme that involves 10,000 species and 75,000 reactions would, in some quarters, be considered a bit of overkill. The project should incorporate some sort of rationale for reducing the number of steps, for example by the diagnosis-related group (DRG) method (or some other approach) because it is unlikely that all 75,000 reactions in a scheme will be important. The project does not appear to consider strategies for chemistry reduction. The reviewer added that the computational times noted for the codes evaluated – 90 years for KIVA and open foam, 150 days for commercial solves using sparse systems – seems connected to the use a 52,000 reaction scheme (and therefore 52,000 species diffusion equations that need to be solved simultaneously). Again, such a computational burden is precisely why chemistry reduction is so important. The reviewer stated that the surrogate components listed on Slides 13 and 19 include a list of species was not clear. Some of the species are gas under standard conditions and some are condensed phase. The reviewer said that surrogates for transportation fuels are going to be mixtures of liquids. Please clarify what is meant by the gas species and that the percentages do not add to 100%. The reviewer added that the project focuses on Converge, as does ace012. The reviewer asked if it would it be possible to incorporate the same solver in KIVA or Raptor. The reviewer also asked what the commercial chemistry solver referred to was. The LLNL model was verified against some basic configurations including a counter flow flame, RCM and SCE tests, which is good.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that the coordination with the leading engine software vendor is outstanding, but a broader base touching more tools (KIVA, etc.) and even vendors (CD-adapco, ANSYS, etc.) is encouraged. Of course, this is limited by the willingness of these other toolmakers to get engaged, but this reviewer has no doubt that more progress and greater efforts to make this work known to the modeling community will generate such interest.

Reviewer 2:
The reviewer indicated that the integration and beta testing in converge is very good. More direct interaction with the industry players to help them integrate these tools into their work processes should be pursued as well. The reviewer added that the project team further demonstrated code integrations would also be valuable both to increase the reach of the work and to uncover other problems in codes as the additional integrations are worked on.

Reviewer 3:
The reviewer said that a long list of collaborators is indicated. It was not clear in some cases what the collaborators provided or what the PI provided them. For example, nine academic partners are listed. The reviewer asked what these partners will provide. The reviewer also asked how collaboration is coordinated with them. Additionally, the reviewer expressed a need to know if the collaborators received some funding from this project and what Bosch provides, etc., and suggested that more details showing the substance of the collaborations would be beneficial.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer stated that there is a good set of plans that directly feed into broad distribution of the tools and which also progressively attack the various weaknesses in the current simulation tools.

Reviewer 2:
The reviewer commented that the proposed expansion to spray dynamics, etc. is welcomed and timely.

Reviewer 3:
The reviewer noted that a capability for spray dynamics is an area that needs further work for computation. The reviewer then asked does the PI have any insights on what his efforts can contribute to simulating sprays. Some of the future work involves further development of advection algorithms and a website to assist with modifying combustion chemistry, this is good. The reviewer added that in performance of an engine, one can envision that a coupling of the internal fluid/transport/reaction dynamics with materials integrity issues is essential for an accurate predictive capability. This project seems not to deal with the conjugate gas/solid interactions that address this concern. The reviewer said the operation at peak engine efficiency, with operational conditions identified by, for example, the outcome of the PI's simulation efforts, could conceivably impose conditions that the materials could not withstand. Materials stress and fracture dynamics are intimately tied to temperature, which is an output of the present simulations; however, the boundaries of the solution domain consist of real materials with finite limits on their integrity. Also the reviewer said it is strongly recommended, going forward, that the PI begin to think about how his efforts can fold into the simulation of engine performance the materials stress issues that can be important for engine durability.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer stated that higher speed and fidelity simulation tools are a key need for enabling continuing development of high efficiency engines.

Reviewer 2:
The reviewer reported that if one believes that better simulations leads to better engine designs which are more efficient (reducing petroleum consumption), then being able to do those simulations faster will speed the process even further.

Reviewer 3:
The reviewer commented that this project is relevant to the DOE's interests because it seeks to develop the ingredients to an efficient predictive capability for an internal combustion engine.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer said that expanding resources through CRADAs and other collaborative projects is encouraged.

Reviewer 2:
The reviewer stated that there appears to be a good rate of progress that is in line with the funding amount. It is not clear that more funding would substantially increase the work rate.

Reviewer 3:
The reviewer stated that the budget seems sufficient; when viewed in the context of complementary projects for example, ace012, it begs the question of why ace012 and ace076 are distinct or could not be folded together into one larger effort. Also, the reviewer said that some further discussion would be useful of how the costs are (broadly) divided among the project team.

Cummins/ORNL-FEERC Combustion CRADA: Characterization and Reduction of Combustion Variations: Bill Partridge (Oak Ridge National Laboratory) - ace077

Presenter

Bill Partridge, Oak Ridge National Laboratory.

Reviewer Sample Size

A total of five reviewers evaluated this project.

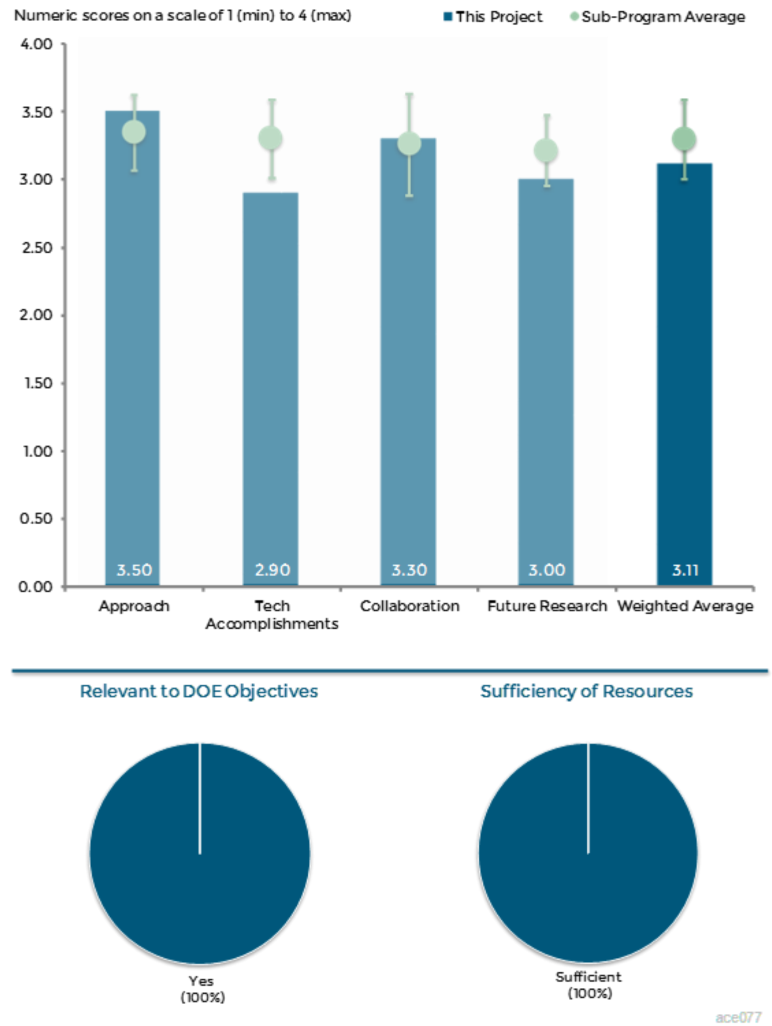

Figure 4-33 Cummins/ORNL-FEERC Combustion CRADA: Characterization and Reduction of Combustion Variations: Bill Partridge (Oak Ridge National Laboratory) – Advanced Combustion Engines

Question 1: Approach to performing the work–the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that the work in this project has done some very good work in developing diagnostic tools which enhance our understanding of engine physics, and also make use of them in very practical ways that can be tied into real product improvements. This is a great example of DOE funding positively impacting products that are going to market.

Reviewer 2:

The reviewer stated that the approach for conceiving and then developing the prototype probe has been excellent. The combination of experimental measurements and CFD for the valve overlap period was very insightful for sorting out the capability of the probe to discern external EGR versus trapped residuals.

Reviewer 3:

The reviewer commented that the project seeks to assess fluctuations in cylinder-charge and apply remedies in hardware and control strategies. The results will be improved combustion uniformity and implementation of advanced combustion strategies.

Reviewer 4:

The reviewer explained that this project, which began in 2013, concerns a range of tasks that include developing diagnostics to resolve in-cylinder thermal/fluid processes. A CRADA has been developed with Cummins to collaborate on the work and technology transfer. The reviewer stated that the approach has apparently been to develop a diagnostic to assess in-cylinder flow and thermal uniformity and to apply it to assess specific hardware architectures and acquire data to tune and improve simulation tools. The problem with this presentation may have been that the PI seemed to assume that the audience was quite familiar with the project and the approach, for example, for CFD precisely what code was used was unclear, et etc. c.); however, for some not familiar with the project it came across as rather like a kitchen sink approach to address a plethora of issues the quantifiable connection of which to engine efficiency and FE was in some cases hard to see. The reviewer added that the project includes a lot of tasks and subtasks associated with combustion uniformity, engine controls, diagnostic development, modeling, emissions characterization, durability and detailed modeling. Much seemed to revolve around, or rely on, the efficacy of a laser problem developed previously to provide data that would meet the PI's objectives. The reviewer also said that one of the figures had an arrow of the various components of the project that point to an engine, apparently on the understanding that somehow, what comes out of the subtasks, for example, hardware, systems control, diagnostics development, engine proof, etc., would lead to a clean, fuel-efficient, durable engine in the marketplace. This is unclear. Project management should do more than make broad links to efficiency. The reviewer pointed out that the presentation noted the relevance of in-cylinder charge uniformity that in turn impacts combustion uniformity. It was not clear how a probe positioned at just one location in the combustion environment could assess the extent to which uniformity of anything could be assessed.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer noted that the findings on the backflow versus cool EGR are very interesting, and were well explained to make sense of the flows in the engine. The tool was used in a number of interesting and practical ways to evaluate the flow and EGR distribution in the engine. The reviewer added that this is a key enabler for improving engine designs and ultimately higher efficiency engines.

Reviewer 2:

The reviewer commented that the presented results for the EGR probe were very impressive to date and its ability to estimate residual mass fraction and EGR rate. The only suggestion is to include any cylinder-to-cylinder variation data along with any validation data for the probe's 10% uncertainty capability.

Reviewer 3:

The reviewer stated that the probe is effective in estimating the exhaust gases moving upstream of the intake port during the engine valve overlap. This can be used to estimate the EGR breakdown between internal and external EGR. The reviewer added that some questions arise on the uncertainty evaluation of the measurements. The authors verbally did not seem to be concerned by the uncertainty of the measurements, for example, benchmarking the optical technique with gas analyzers) and were unable to explain the translation of the percent CO_2 concentration to actual mass of flow estimation (the event is highly transient). The reviewer also said both of these issues are a concern for evaluating the technology and should be addressed by the authors with more rigor.

Reviewer 4:

The reviewer pointed out that a laser probe was used to analyze in-cylinder charge components, modifying the probe to resolve backflow measurements, measuring emissions as a function of crank angle, and assess advanced in take architectures (vague, because architectures was not clear) among other things. The reviewer commented that a large part of the presentation seemed to involve tasks associated with using this probe (indeed, much seemed to rest on this probe meeting some project goals). The capability to measure CO_2 and water (H_2O), along with temperature and pressure for the in-cylinder environment would, of course, be good. The reviewer indicated that there are two issues that are raised by this probe development effort. First, the probe appears to provide data at just one fixed location in the intake runner. The reviewer asked if this is this a problem. One of the little images of the intake runner shown in Slide 10 seems to suggest some spatial distribution in the intake runner space. Unless the PIs choose the right location to mount the probe, the results could change and might affect the data. The reviewer added that there does not seem to be a capability to map out the emissions or thermal field in the cylinder, which would be very useful information.

Secondly, the reviewer said the probe does not appear to be especially small, or at the least no information was provide on the potential for the probe itself to influence the flow pattern in the intake runner environment by the physical volume it occupies. It would be useful to provide some measurements of the flow field around the probe to establish that the probe itself is not effecting the distribution of gas species or the temperature field, as it was unclear if its physical presence displaces gas that could affect the flow pattern. Thirdly, the reviewer asked if the authors have considered nonintrusive diagnostics. SNL (Livermore) has some capabilities, and perhaps even ORNL. If so, it would be valuable to compare, say, probe temperatures with similar measured by non-intrusive means. The reviewer stated that some modeling work was presented to predict the evolution of CO_2. The presentation noted 3D-CFD model results. No details were provided. The reviewer stated that more information on the modeling effort should be provided. Making in-cylinder predictions is not well established (other VTO projects are developing detailed simulation capabilities), and the inputs to the codes have a strong effect on the predictions, for example, combustion chemistry of surrogates for gasoline or diesel, thermal physical properties, etc.. Also, the codes need to be validated before they are used. These are not trivial considerations.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer commented that the partnership with Cummins has been very good and there is clear tie-in between ORNL and Cummins. The reviewer would like to see even more expansion of the outcomes of this program into other DOE lab programs; ANL and ORNL engine work could make use of the project results quite effectively.

Reviewer 2:

The reviewer pointed out that this work within the CRADA appears to be quite well coordinated with the key industry partner and a couple other research organizations. It might strengthen the project to include other engine OEMs.

Reviewer 3:

The reviewer stated that this project is a CRADA with Cummins and it is interfacing with the Cummins SuperTruck program. The project team is very accomplished and well known. The reviewer added that it was sometimes a bit unclear how specific results from one part (for example, ORNL) would be used by the other (Cummins).

Reviewer 4:

The reviewer stated that the work presented is practical and valuable. It is an example of a well-run CRADA. The work studied back-flow measurements via a multi-color EGR probe.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that much of the proposed work is refining the tool. This is a good goal and important work, but the reviewer would like to see more development of new tools as part of the CRADA as well. Some of the stretch goal ideas could be pulled forward into the prime path of the project usefully.

Reviewer 2:

The reviewer pointed out that the future work is indicated. It would be important to develop approaches on how to use the information provided to limit the variability on flow. The reviewer added that it will be important to understand how this variability influences or deteriorates engine efficiency.

Reviewer 3:
The reviewer stated that the proposed research is reasonable for further developing the EGR probe. It would be helpful to include cylinder-to-cylinder variation in future work, too for assessing each cylinder's contribution to PM and NO_x.

Reviewer 4:
The reviewer commented that the future work was framed in terms of considerations of what would be needed to improve performance of the probe (improve signal-to-noise ratio, apply it to various engine platforms), develop new data for parameters relevant to engine uniformity, measurement campaigns at CTC for hardware and system control, compare results. The reviewer asked comparing the results of what. The reviewer asked what these models are for the model-based expectations. The reviewer asked what develop stretch technologies means. The reviewer asked what will be done with the data for mass flux and cylinder head temperature. These were somewhat vague.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer stated that this work promotes useful techniques and instrumentation to better understand and benchmark engine performance.

Reviewer 2:
The reviewer noted that this project indirectly supports DOE goals by providing engine OEMs a diagnostic to develop improved air systems toward reducing emissions in future engines. Also, the probe might be able to aid in better transient EGR control strategy development as one looks into the future.

Reviewer 3:
The reviewer indicated that there is key linkage between the project and the goals to reduce petroleum use. Cummins has clearly demonstrated good tech transfer from DOE to their work, and others likely are as well.

Reviewer 4:
The reviewer commented that the capability to monitor internal flow processes is important for improving performance of the ICE. The matter here is if the probe used in this study is the best instrument for that purpose. The reviewer stated that given that it, apparently, cannot provide spatially resolved measurements, a high reliance on identifying the most suitable location for data extractions is needed. This consideration could limit its usefulness. The reviewer added that nonintrusive diagnostics are important though difficult to apply.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer indicated that the funding level appears to be good; the reviewer is fairly certain that some more progress could be made with additional funding though.

Reviewer 2:
The reviewer stated that for what is included in this project, it is a relative bargain at $250,000 per year. Other projects that, for example, deal with only computational efforts have budgets in excess of double this project, which includes tasks associated with both experiments and modeling.

Investigation of Mixed Oxide Catalysts for NO Oxidation: Janos Szanyi (Pacific Northwest National Laboratory) - ace078

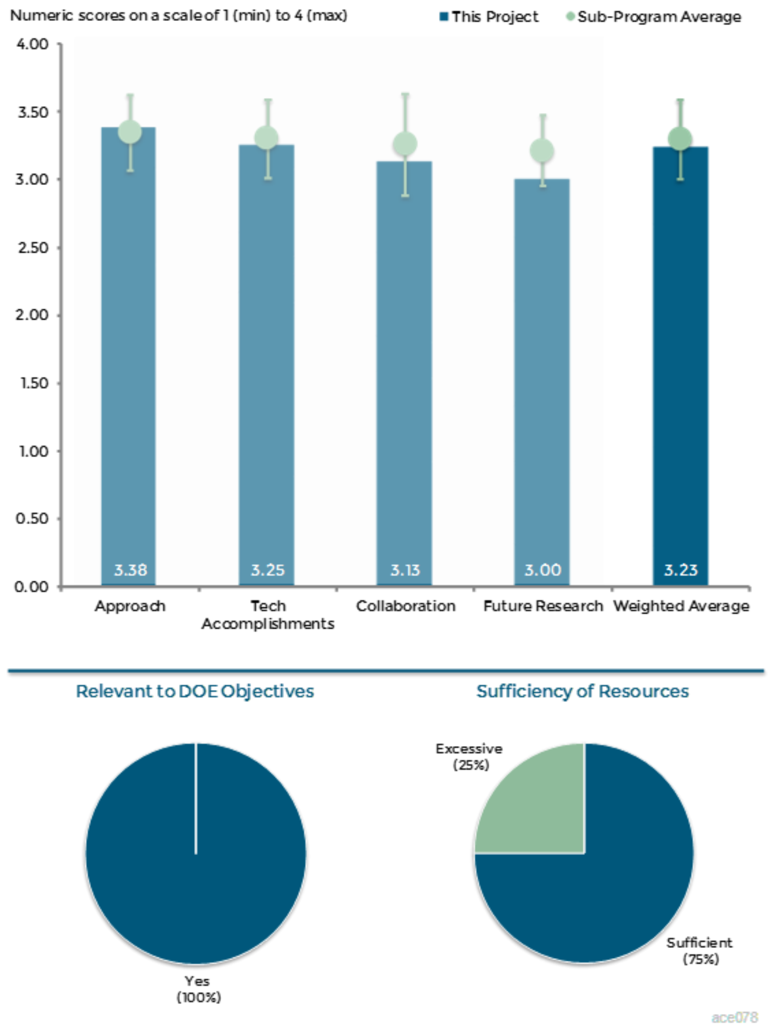

Figure 4-34 Investigation of Mixed Oxide Catalysts for NO Oxidation: Janos Szanyi (Pacific Northwest National Laboratory) – Advanced Combustion Engines

Presenter

Janos Szanyi, Pacific Northwest National Laboratory.

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that the approach of using a bank of methods to characterize these catalysts was very effective.

Reviewer 2:

The reviewer commented that the project team had an excellent approach to develop advanced catalyst formulations to evaluate both fresh and lab-aged catalyst materials to optimize the formulations for diesel oxidation catalyst (DOC) and lean NO_x trap (LNT) applications considering low-temperature catalyst light-off performance targets and using materials other than the platinum metal group (PGM).

Reviewer 3:

The reviewer pointed out that a strong and scientific approach was taken to understand the manganese dioxide (MnO_2)-Cerium oxide (CeO_2) system for nitrogen oxide (NO) oxidation. The isotope labeling studies were very effective for probing the lability of the oxygen on the catalyst. The reviewer added that the $M2O_2$ loading studies were effective for determining the portion of MnO_2 that is effective for NO oxidation. The different synthesis methods were good for investigating whether a mixed oxide of ceria and manganese was necessary or could the simpler process of post-impregnating manganese on ceria result in a catalyst that was effective for NO oxidation. The reviewer stated that the combination of reactor studies, density functional theory (DFT) calculations, catalyst synthesis methods, and Fourier transform infrared spectroscopy (FTIR) methods demonstrated a strong and effective scientific approach to catalyst development.

Reviewer 4:

The reviewer explained that investigating lanthanum perovskites and MnO_2 in such detail, when both are known to have severe sulfur poisoning issues, is not a great starting point. Even if either had a 50/50 chance of solving the problem, the combined probability would be less than 15%. The reviewer said it is just not a great starting point, no evidence of success was shown.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer remarked that the project team had excellent progress applying catalysis expertise, state -of-the-art analytical techniques, computational analysis to investigate surface and bulk properties of the catalyst materials with respect to changes in composition and interaction between reactants and the potential active sites while supporting very promising manganese oxide (MnO_x)/CeO_2 formulations with 50-60% NO oxidation light-off performance at 200°C and very limited hydrothermal aging impacts. Although surface area measurements show 30-40% loss due to aging, aging has little effect on catalyst activity. The reviewer added that the project team did excellent work to incorporate zirconium dioxide (ZrO_2) into MnO_x-CeO_2 mixed oxide showing increased catalyst activity, improved hydrothermal aging, and increased sulfur tolerance with 70% of the conversion restored by a rich treatment.

Reviewer 2:

The reviewer stated that there was a great accomplishment for using the labeling studies to demonstrate the stronger lability of the oxygen on the manganese/ceria catalyst relative to that of ceria alone. The loading study work clearly showed that it is the surface manganese that is effective for NO oxidation. The reviewer added that a particularly good accomplishment was showing that the simpler process of impregnating manganese on ceria produced a catalyst that was as effective for NO oxidation as a catalyst prepared by the more complicated approach of doping manganese within the ceria matrix. Another accomplishment was the incorporation of zirconia into the formulation to improve its thermal stability; however, a much greater investigation into the effects of thermal aging, sulfur poisoning, and desulfation characteristics needs to be demonstrated. The reviewer warned that without thermal durability and an effective desulfation process, the catalyst could never be used on a vehicle.

Reviewer 3:

The reviewer commented that the project team did nice work on the surface analysis. It does provide guidance for future work on other systems. The reviewer added that DFT was mentioned, but few results were shown.

Reviewer 4:

The reviewer commented that the increased understanding of MnO_2 and its interaction with ceria has come from this work. More work with sulfur tolerance is needed.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer said excellent CRADA partnership with GM, PNNL and Tianjin University.

Reviewer 2:

The reviewer said that this project was basically a three institution effort, with no other collaborators, so it could have somewhat broader in the efforts by the PNNL partners, particularly in China.

Reviewer 3:

The reviewer commented that there was clearly a good division of effort between PNNL and GM, where GM focused on the catalyst formulations and reactor testing and PNNL focused on catalyst characterization and synthesis methods.

Reviewer 4:
The reviewer reported that GM apparently was a major initial partner, but they were not included in the report. The DFT was apparently done at a university in China, but was only verbally acknowledged.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer pointed out that the research is complete for this excellent case study CRADA. Future similar activities to reduce or optimize aftertreatment (LNT, DOC, diesel particulate filer [DPF]) catalyst PGM usage, develop low-temperature aftertreatment oxidation catalysts and better characterize active site micro-structure in oxidation catalyst to effectively model and design productive future catalysts using small focused working group is strong recommendation for future work.

Reviewer 2:
The reviewer recommends that the work continue with an emphasis on improving the thermal durability and the desulfation capability of the catalyst.

Reviewer 3:
The reviewer stated that the contract is over, so there will be no more work in this specific project.

Reviewer 4:
The reviewer said not relevant; better initial thought on the project would be preferred.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer stated that advanced aftertreatment with reduced or eliminated PGM materials resulting in lower cost aftertreatment solutions and lower temperature performance can enable the use of advanced combustion strategies in a production environment.

Reviewer 2:
The reviewer pointed out that such a catalyst could allow lean operation on gasoline or diesel applications while allowing a reduced cost aftertreatment system to achieve strict emission standards.

Reviewer 3:
The reviewer commented that replacing platinum (Pt) would help in accomplishing better FE.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer said excellent result and use of budget.

Reviewer 2:
The reviewer commented that the project goals appeared to be satisfied and that the project is discontinued.

Robust Nitrogen Oxide/Ammonia Sensors for Vehicle On-board Emissions Control: Rangachary Mukundan (Los Alamos National Laboratory) - ace079

Presenter

Rangachary Mukundan, Los Alamos National Laboratory.

Reviewer Sample Size

A total of five reviewers evaluated this project.

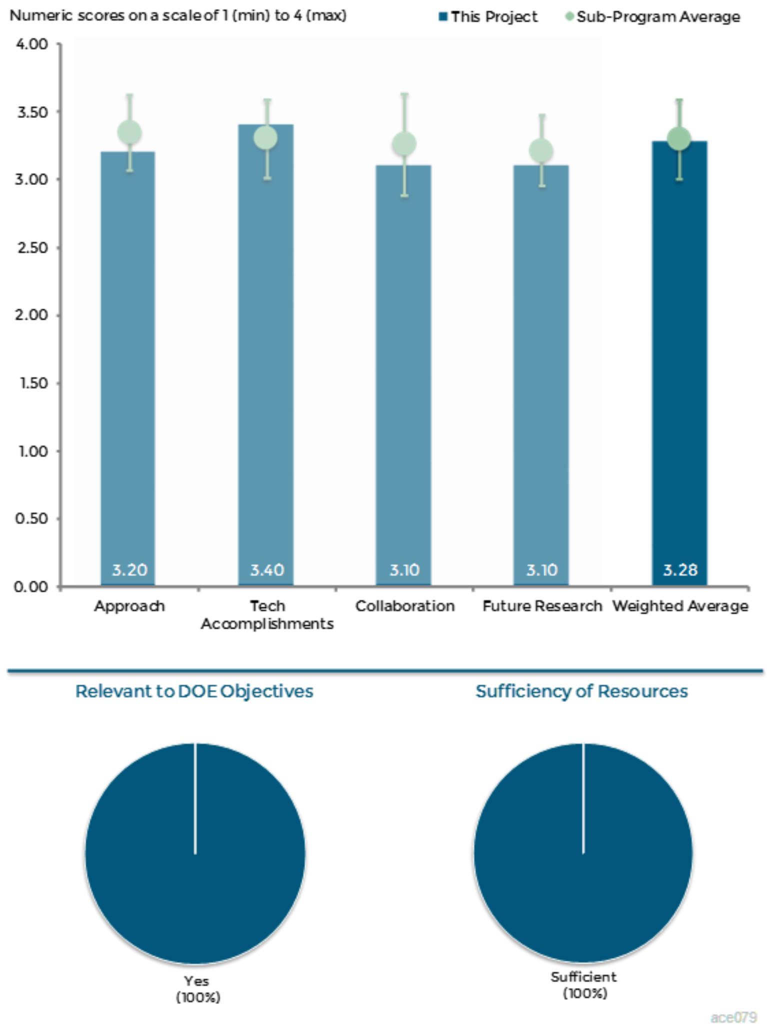

Figure 4-35 Robust Nitrogen Oxide/Ammonia Sensors for Vehicle On-board Emissions Control: Rangachary Mukundan (Los Alamos National Laboratory) – Advanced Combustion Engines

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commented that there was an excellent collaborative approach adopted to overcome the technical barriers. The adopted approach seeks to solve key issues to commercialize low cost NO_x sensors for vehicle applications.

Reviewer 2:

The reviewer said the project seems to be well connected with current sensor manufacturer and well aware of what is needed for commercialization.

Reviewer 3:

The reviewer said that this project is well thought out and technically sound. Even though it is set out to overcome the barriers mainly in NO_x measurement. The reviewer added that the potential of the sensor could also measure NH_3 and HC is very beneficial in the future. At the same time, the sensitivity of the sensor in measuring NO_x seems to be influenced by many factors. The project is still quite a distance away from the target of plus/minus five parts per million (ppm) or better.

Reviewer 4:

The reviewer pointed out that NO_x sensors that meet stringent vehicle requirements are available and are on every post-2010 medium- and HD diesel and every post-2008 LD diesel sold in the United States. While the reviewer understands the need for improved NH_3 sensing, it is difficult to understand the manner in which the nearly ubiquitous position of NGK as an original equipment zirconia-NO_x sensor supplier for the past 5-7 years was completely ignored when setting project goals. The reviewer asked how is this approach fundamentally better than what is currently in use by engine and vehicle manufacturers.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:
The reviewer reported that significant progress has been made with sensor related development. The project is on track against milestones. Letters of Interest from a variety of OEMs, Tier 1 suppliers and sensor development companies show general acceptance of the sensor concept. The reviewer added that input from a broad range of stakeholders would be valuable and helps to the move the sensor toward commercial use.

Reviewer 2:
The reviewer stated that this project has already achieved 85% of its goal towards developing robust NO_x sensors for vehicle on-board diagnosis and control. Investigators have successfully carried out engine evaluations and sensor packaging studies. The reviewer added that this is significant progress towards a commerciality viable sensor for on-board diagnostics (OBD) applications.

Reviewer 3:
The reviewer remarked that there was surprisingly good NH_3 selectivity.

Reviewer 4:
The reviewer stated that this project is actually fascinating work. Very competent in the work being done.

Reviewer 5:
The reviewer commented that it is not clear how the cross sensitivity to HC will be solved to make the sensor useful to measure NO_x and NH_3.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer stated that collaboration and coordination with universities, industry partners, and national laboratories has been excellent. The efforts in seeking commercialization has been fruitful.

Reviewer 2:
The reviewer stated that there was excellent collaboration with laboratory, university, and vendor participation with a Tier I/OEM partner identified for further development.

Reviewer 3:
The reviewer said that steps toward commercialization are very important.

Reviewer 4:
The reviewer commented that having a close partnership with a major sensor supplier (Bosch, NGK, Denso, and Delphi) will be critical to proceeding into later stages of development and will be absolutely necessary for commercialization.

Reviewer 5:
The reviewer noted that the project is very well tied to the organizations that matter for this project.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that this type of project is really well aligned with the car/engine manufacturers need to satisfy the emission controls. Much work in the SCR field today is about discerning the difference between NO_x and NH_3. The reviewer added that this sensor should eliminate the ambiguity.

Reviewer 2:

The reviewer commented that the proposed future work is reasonable. Given the fact only a few months are left for the project, focus should be placed on improving the sensor sensitivity.

Reviewer 3:

The reviewer commented that future work is focused more towards sensor tolerance towards impurities and real driving situations. A major portion of this work is to commercialize the sensor technology for closed loop control, which may take time.

Reviewer 4:

The reviewer observed that it will be crucial to improve the accuracy of the sensor and figure out how to eliminate or work around the HC cross sensitivity.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer stated solving emission controls allows OEMs to push engine out up, ensuring more efficiency but, still be compliant.

Reviewer 2:

The reviewer said that if successful, the technology would results in fuel saving that would support DOE objectives of petroleum displacement.

Reviewer 3:

The reviewer stated indirectly, as goals are more focused on the emissions control problem, but as emissions control and FE get interrelated in the engine design process, success here will ultimately aid building better engines which consume less petroleum.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said that the project was done on time and within budget, must be good.

Reviewer 2:

The reviewer noted that that funding seems to be adequate for the remaining tasks.

Reviewer 3:

The reviewer stated that resources seem adequate.

High Efficiency GDI Engine Research, with Emphasis on Ignition Systems: Thomas Wallner (Argonne National Laboratory) - ace084

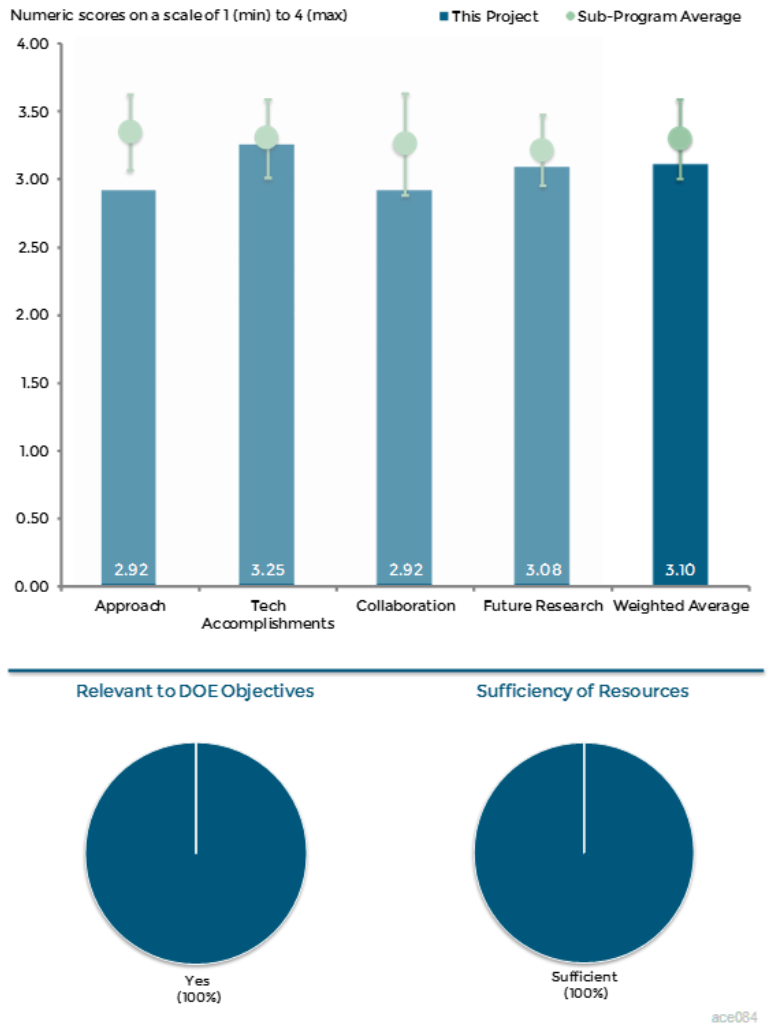

Figure 4-36 High Efficiency GDI Engine Research, with Emphasis on Ignition Systems: Thomas Wallner (Argonne National Laboratory) – Advanced Combustion Engines

Presenter

Thomas Wallner, Argonne National Laboratory.

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer explained that the study focusses on dilute gasoline combustion, a combustion pathway on the U.S. Driving Research and Innovation for Vehicle Efficiency and Energy sustainability (U.S. DRIVE) Advanced Combustion and Emissions Control ACEC Roadmap, which is commended.

Reviewer 2:

The reviewer pointed out that the overall approach has been excellent to date including both experimental and analytical approaches. The only suggestion the reviewer has is to explore other potential important engine operating conditions to assess the various ignition systems.

Reviewer 3:

The reviewer remarked that the approach is very solid. The project seeks to overcome the barriers to robust lean-burn and EGR-diluted combustion technology and controls. The reviewer added that the area is relevant to boosted and down-sized engines. The work looks to ignition systems (solid state lasers) and their potential use with lean/dilute combustion. Finally, work focuses on development of modeling tools. The reviewer also said the work is relevant as dilute spark ignition (SI) combustion offers the great potential for decreasing fuel consumption. The authors present Honda’s valuable and recent reference, indicative of the current standard.

Reviewer 4:

The reviewer observed that the goal of increasing the dilution limit for lean and high-EGR engines is valuable, but the industry has already done a great deal of work in this area in the pursuit of these combustion systems. Laser ignition has been investigated for decades now, and many of the plasma/corona systems have been developed to near-production readiness by the Tier 1 suppliers. The reviewer added that the additional evaluations by DOE seems to be somewhat duplicative of work that is already being done. The modeling tool evaluation/development to capture the stochastic nature of high dilution combustion is valuable and should be a long-term investment in enabling better dilute engines.

Reviewer 5:

The reviewer commented that the approach was assessing the compatibility of advanced ignition systems with lean or dilute combustion systems, developing modelling tools to rapidly screen new designs, and studying combustion stability issues seems appropriate.

Reviewer 6:

The reviewer commented that the conventional coil ignition may not be the best baseline. The reviewer understood that it is readily available, but it is important to be able to compare to spark plug based systems with improved coils that ignition system manufacturers are working on. These are the systems that are relevant as a comparison.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer listed the good progress including establishing the minimum number of cycles required for stability assessment, demonstrating that Reynolds-averaged Navier Stokes (RANS) can be used as a tool for combustion stability assessment, and experimentally showing that lean cases are more sensitive to perturbation than baseline and EGR dilute cases.

Reviewer 2:

The reviewer observed that the authors have made good progress in this calendar year across a range of tasks and the work is well documented. The author's study of stability addresses first the use of a statistical evaluation of multi-cycle experimental data to establish a minimum cycle number for stability. Secondly, the work evaluated stability through perturbation of ignition energy and timing. The reviewer added that this is a good lead in to the simulation validation, which established RANS as a tool for combustion stability assessment. The study shows the effect of the variability of the in-cylinder flow from cycle-to-cycle and correlates it to the experimental engine data. The reviewer commented that it appears that the variability introduced is limited to the flow variability. The reviewer suggested that the authors comment on why the variability is limited to flow and not include the fuel quantity or ignition variability. Overall, the results do show that the multi-cycle RANS modeling correlated to experimental data at least qualitatively. The authors compared the RANS performance with LES, indicating that LES provides only minor improvements. The reviewer added that with regards to extending the operation regime of EGR dilution, the work has yielded limited success. The authors completed installation of a laser ignition through spark-plug geometry. The reviewer pointed out that tests were carried out to understand the impact of multi-pulse operation and separation between pulses. Results indicate limited impact. The reviewer commented that the level of laser energy was also reported and overall indicated that it does not significantly improve dilution tolerance either. Tumble ratio did not affect stability either tough influenced other combustion metrics. Additionally, the reviewer said that the interaction between ignition and flow were simulated with emphasis on multi-point laser ignitions. These later results suggested improved efficiency and reduction of variability. The reviewer also stated that the later ignition system characterization included a non-equilibrium plasma system. These results indicate improvement of dilution tolerance, significantly better than the conventional spark.

Reviewer 3:

The reviewer commented that the RANS modeling results were interesting, as was the comparison with the LES models. It is somewhat odd that LES predicts such high cycle-to-cycle variability (CCV) for non-dilute operation while predicting relatively accurate CCV for dilute. That suggested to the reviewer that the model is not predictive at all really. The reviewer added that the three-point laser ignition result was interesting. If there is going to be work on laser ignition, it should be on ideas like this that could show some improvement and which may be different from the long history of laser ignition research.

Reviewer 4:
The reviewer stated that the laser results are interesting but do not suggest that laser ignition will ever be better than electrical systems. The reviewer added that a key question for a laser based system is how to keep the access window clean.

Reviewer 5:
The reviewer commented that this project has derived new insight on CCV from a simulation perspective that could useful outside the context of this particular project. Work during the past year has been insightful for assessing laser ignition and one plasma approach and their ability to extend the EGR limit at one key engine operating condition.

Reviewer 6:
The reviewer reported that it is concerning to see sporadic misfires in some of the data shown. Either the misfires should be included as part of the research interest because it is of interest to understand the dilute limit, or the cause of the sporadic misfires should be investigated as a possible malfunction and eliminated. The reviewer added that the input energy requirement for each of the ignition systems tested should be shown. It is understood that it is beyond the scope of this study to reduce parasitic loss associated with highly experimental ignition systems, but it would still be good to know.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer stated that there was wide collaboration, including an engine OEM, modeling player and ignition system developers.

Reviewer 2:
The reviewer commented that good collaboration exists with Ford.

Reviewer 3:
The reviewer said that there is a reasonable level of collaboration with other national laboratories and one LD company. Possibly the project could benefit from additional collaboration with other LD companies if such companies could supply ignition system hardware for evaluation purposes in comparison to recent past work.

Reviewer 4:
The reviewer reported that there were a limited number of collaborators that include one automaker, one simulation software company and two national laboratories. No specific information given to evaluate frequency and quality of those collaborations.

Reviewer 5:
The reviewer indicated that there really needs to be substantial interaction with the Tier 1 suppliers of ignition systems if this project is going to be useful. There needs to be a comparison of any non-conventional ignition system with not only a traditional production-style system but with an inductive system, which is specifically intended for dilute operation (BorgWarner, Diamond Electric, Denso, etc.). The reviewer added that with so much industry work in this area, not having extensive interaction with industry will lead to duplicate work which may not extend the knowledge base at all.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer remarked that the ignition modeling work is good; there is a huge need for good predictive ignition models. More details on this would be nice to have. The reviewer added that the ignition system

testing should have an ongoing interaction with industry and also a continuing evaluation of existing published research so that it is clear how this project is going beyond studies that have already been done by others.

Reviewer 2:

The reviewer indicated that the improved ignition models are an important area and are needed by the industry.

Reviewer 3:

The reviewer stated that the plans seem reasonable for continued progress towards project objectives.

Reviewer 4:

The reviewer commented that the future work addressed clear challenges and barriers, including the absence of consistent guidelines for advance ignition systems, procedures to evaluate ignition systems, and modeling approaches.

Reviewer 5:

The reviewer suggested considering exploring other engine operating conditions (such as lighter loads) with the various ignition systems.

Reviewer 6:

The reviewer asked if there is a way to get the engine to operate at 35% EGR and closer to 45% BTE like Honda has demonstrated. Applying novel, advanced ignition systems like laser based and non-equilibrium plasma systems will then have more significance as to their potential.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer reported that there is potential for significant short-term improvements in FE if dilute combustion can be pushed into the market. Ignition systems and modeling tools are a key enabler for this. The reviewer added that there are ways this project can contribute to what is already going on in this area.

Reviewer 2:

The reviewer commented that extending the operating range of lean burn and EGR-diluted SI engines would improve FE and thus support DOE goals of limiting petroleum usage.

Reviewer 3:

The reviewer observed that this project is more near-term based aimed at understanding and pushing the dilute limit for modest improvements in engine efficiency, but can be applied over a large fraction of the North American fleet.

Reviewer 4:

The reviewer stated that this project supports development of more efficient gasoline power plants.

Reviewer 5:

The reviewer said that this project supports possible future development of lean-burn, DI gasoline engines that might be able to challenge DI diesel overall efficiencies for LD use.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer indicated that the funding level appears correct relative to the work plans. The reviewer would prefer to see the funding devoted more to the modeling development or to experiments which are unique from what has been published elsewhere.

Low-Temperature Emission Control to Enable Fuel Efficient Engine Commercialization: Todd Toops (Oak Ridge National Laboratory) - ace085

Presenter

Jim Parks, Oak Ridge National Laboratory.

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

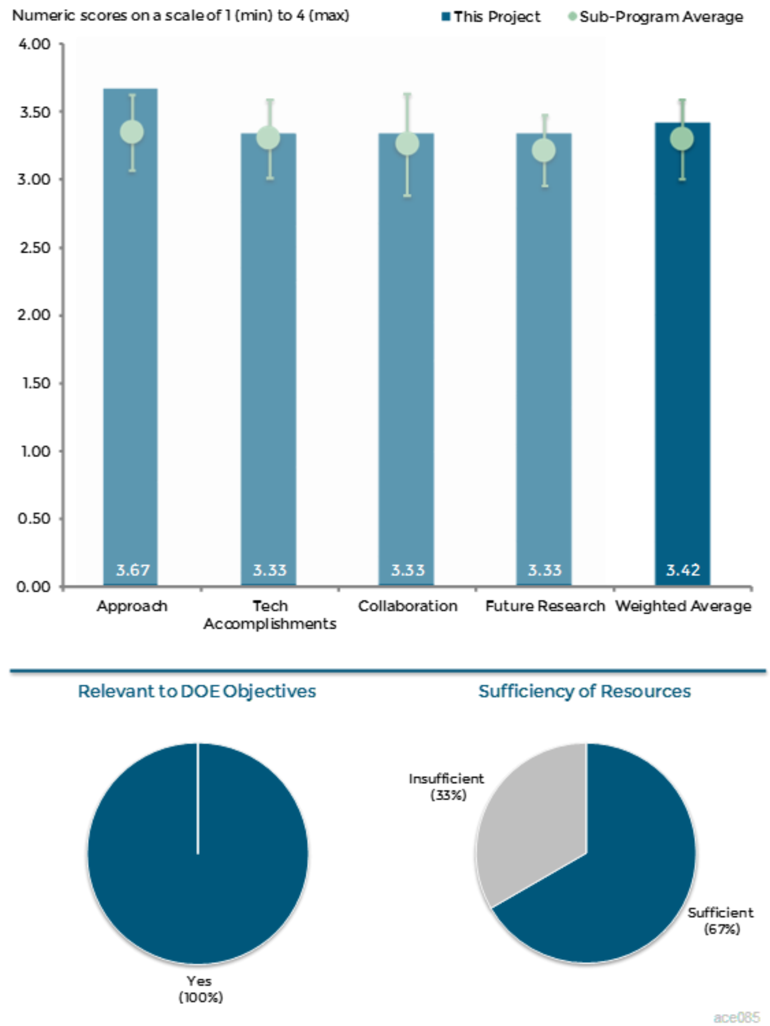

Figure 4-37 Low-Temperature Emission Control to Enable Fuel Efficient Engine Commercialization: Todd Toops (Oak Ridge National Laboratory) – Advanced Combustion Engines

Reviewer 1:

The reviewer observed that this project takes an excellent approach in addressing the challenges in low-temperature emissions control. The steps taken are logical. The reviewer added that candidate materials chose so far are proper based on the scope of this study. Further narrow down in number of material candidates would save time and speed up the project. The process and techniques of evaluating the material are excellent.

Reviewer 2:

The reviewer stated that the overall approach makes sense to expose the candidate catalysts to realistic conditions (hydrothermal aging and sulfur poisoning) as these are the key technical challenges for base metal- (copper (Cu), cobalt (Co) etc.) based catalysts.

Reviewer 3:

The reviewer commented that the project team took the classical approach, literature, synthesis, evaluation. High risk/high reward is likely needed here – entirely different approaches to break the low-temperature barrier. The reviewer added that the project team should have a fundamental understanding first, then iterate. CO poisoning is main obstacle, but realistic exhaust approach and test protocol critical to move into practical application.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer reported that the project team had an interesting early promise on CO/HC inhibition with the co-precipitated CuO_x, CoO_y, and CeO_2 catalyst (CCC). Excellent investigation on dual site mechanism. The reviewer said that the project had a very high caliber work. This could open up other catalyst designs. The reviewer added that aging studies are preliminary, but shows acceptable high-temperature durability for LTC engines. Combo Pt)/aluminum oxide (Al_2O_3) and CCC is logical and delivered results, excellent start. The reviewer also said the palladium /ZrO_2/SiO_2 work is showing some progress from significant work on fabrication. Further options exist for improvement. The reviewer observed that the HC trap concept offers further options worth investigating. Promising results with novel silver (Ag) addition. The reviewer indicated that the project team had a new approach delivering results, good start. The project team claimed to have begun the SCR work but show no plans or data. Yet, the project team has only a half-year to complete this work from when this presentation was put together. The reviewer is suspicious if the project team is really on track as shown on Slide 9.

Reviewer 2:

The reviewer said that good progress has been made in synthesizing and evaluating HC and NO_x trapping materials as well as identifying the individual roles of the of the components in the CuCoCe ternary oxide and potential synergy with standard emissions control components. The findings have been very insightful. Systematic selection of material based on literature review of key journals is an improvement. The reviewer added that more involvement from catalyst suppliers would be sensible as a best practice may not be found in literature in a timely manner.

Reviewer 3:

The reviewer commented that although the critical importance of catalyst durability have been stated by the PI, no data was presented on the effect of sulfur exposure on the CCC catalysts and the hydrothermal aging conditions were rather mild for gasoline engine applications. The synergistic effect of Pt and CCC catalysts was an interesting finding and a more detailed mechanistic study is needed.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that the various collaborators have the needs covered, excellent. Use of BES for fundamentals, Johnson Matthey for practical/fundamental interface. The reviewer noted cross-fertilization with Ford TWC project.

Reviewer 2:

The reviewer said that more regular technical interactions with industrial partners will help to better define the critical technical challenges (sulfur and severe hydrothermal aging conditions).

Reviewer 3:

The reviewer observed that the collaboration and coordination with U.S. DRIVE team, Johnson Matthey and universities have been good. Reaching out to additional catalyst suppliers could be further beneficial to the project.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer reported that the project team had a reasonable plan, but sulfur studies are very critical for CCC and long overdue. The project team has invested heavily in this catalyst, and all this work might be wasted if sulfur effects are significant. The reviewer added at least get a peak in the box before doing any further composition work. This is the risk part of high risk/high return. The reviewer also said that the same is true with the HC adsorber. The reviewer noted that sulfur impacts Ag, and suggested running a couple tests to see if this is a killer.

Reviewer 2:

The reviewer indicated that the effect of sulfur should be the top priority going forward as it is well known that it is the key challenge for PGM-free catalysts.

Reviewer 3:

The reviewer stated that the proposed future work is a natural flow of the project. In some sub-categories which involved multiple choice/combination tasks, the design of experiment technique should be considered to speed up the project.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer commented that this project addresses a key enabling issue with regards to low-temperature combustion engine technology. Low-temperature engines improve FE, which would support DOE objectives of petroleum displacement.

Reviewer 2:

The reviewer stated that the low-temperature catalysts with high efficiencies and durability is a critical enabler for advanced engine technologies.

Reviewer 3:

The reviewer said that oxidation catalysts are emerging as a critical need to enable high-efficiency engines (GCI, RCCI, and LTC).

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that funding seems to be adequate for the remaining tasks.

Reviewer 2:

The reviewer noted that the resources are sufficient to progress the HC/CO oxidation work, but likely not enough for SCR work. The Scope should be re-evaluated. The reviewer added that there is much on the HC remediation plate, and unless more resources are added, the project will miss the NH_3 SCR goals. Otherwise the project will do a partial job on each.

Next-Generation Ultra-Lean Burn Powertrain: Mike Bunce (MAHLE Powertrain LLC) - ace087

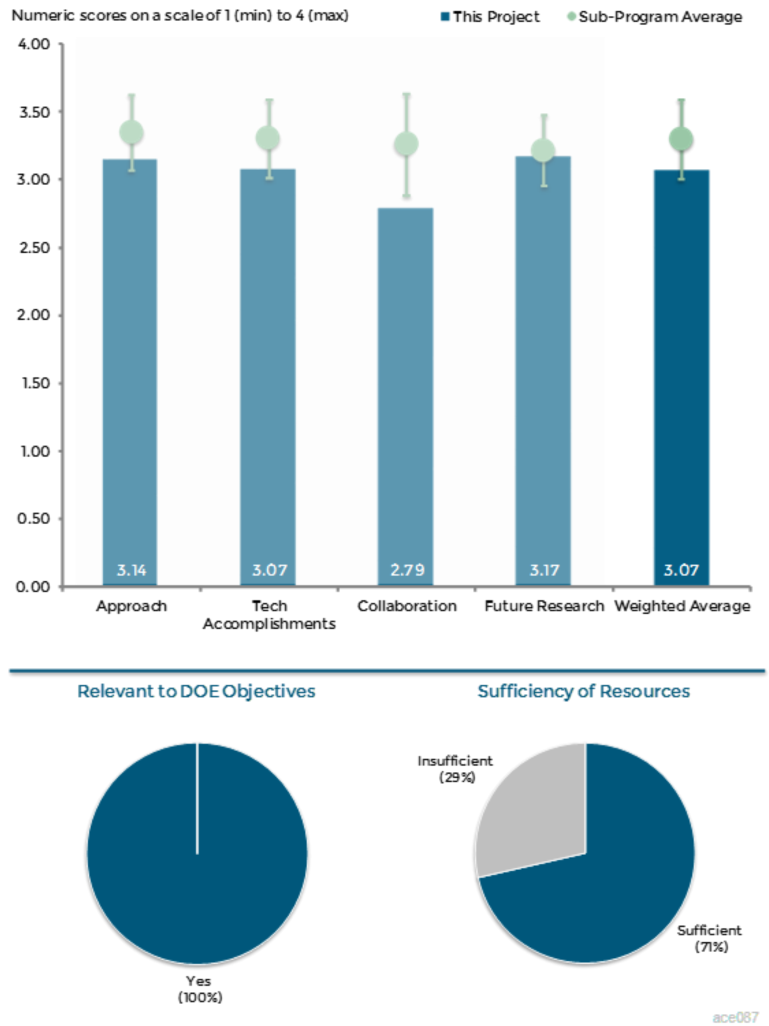

Figure 4-38 Next-Generation Ultra-Lean Burn Powertrain: Mike Bunce (MAHLE Powertrain LLC) – Advanced Combustion Engines

Presenter

Mike Bunce, MAHLE Powertrain LLC.

Reviewer Sample Size

A total of seven reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer observed that the project team had an excellent approach to design the engine and develop understanding of pre-chamber and jet ignition technology to achieve 45% thermal efficiency on a LD SI engine and emissions comparable to or below existing SI engines using CFD models, GT Power, single cylinder dyno, and multi-cylinder dyno to demonstrate aggressive targets. The reviewer added that 30% modeled drive cycle FE improvement over gasoline engine from dyno mini-map. Cost-effective hardware for design and manufacturing considering small changes to existing engine hardware. The reviewer also said it would be outstanding to include actual emission target values used, and a future plan or strawman analysis of the potential use pilot jet technology for other advanced combustion and bi-fuel approaches such as diesel pilot NG.

Reviewer 2:

The reviewer reported that this is a very well rounded program for high efficiency gasoline engine research utilizing a turbulent jet ignition (TJI) combustion system with single and MCE and numerical studies being performed in a highly complementary fashion. CFD has been effectively used to optimize the TJI system on a gasoline engine, while SCE test results have been performed for the pre-chamber design optimization. The reviewer added that a MCE was built and preliminary results show good FE. While most of the results are based on efficiency, more comparison results of emissions would be extremely helpful. The reviewer also stated that cost added to the engine by introducing the TJI system needs to be calculated, including the cost of manufacture, control system and maintenance fee.

Reviewer 3:

The reviewer remarked that the project team had an excellent approach in integrated simulation and experimental development. Any lean-burn system is going to raise questions of how emissions will be addressed with confidence. The reviewer added that this needed a little more attention in the project, but was perhaps out of scope.

Reviewer 4:

The reviewer stated that the overall approach being used for this project appears sound and well thought out. The CFD model of the turbulent jet is said to use species concentration in the main chamber to determine ignition. The reviewer added that it was not clear how this development of the model was done. The reviewer asked if there was there some validation of the model with the optical data.

Reviewer 5:

The reviewer commented that lean combustion is a known approach to improve gasoline engine efficiency.

Reviewer 6:

The reviewer noted that the project is not a new technology, but new tools used to refine it, certainly timely. The approach keeps resurfacing so the reviewer believed it had merit, but needs refinement. The reviewer added that the assumption that NO_x is very high for ultra-lean combustion is not necessarily valid. It depends on the exhaust gas conditions and duration. The reviewer thinks a few NO_x measurements would be informative. The reviewer also said the assumption here is that the aftertreatment will have to fix the NO_x problem is always problematic.

Reviewer 7:

The reviewer reported that it does not look like the 45% thermal efficiency goals will be met. Without understanding how criteria pollutant emissions control will be accomplished with this engine configuration. The reviewer asked how drive-cycle FE could be predicted.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer noted excellent progression through simulation, fundamental experiments, and engineering. Have progressed to multi-cylinder with BSFC numbers looking pretty good. The reviewer asked if the project team is still short of 45%. Still using simulated boosting system.

Reviewer 2:

The reviewer stated that the transition from single cylinder and multi cylinder results are good.

Reviewer 3:

The reviewer observed that good progress has been made against the objectives of the program, with the program going all the way from concept design to MCE testing smoothly and generating very promising results that have been delivered on time. Most of the designed procedures are shown to be very effective. Of particular note is the extensive use of CFD tools to understand the TJI system and to assist the whole engine design. The reviewer asked that because the TJI system has a more constrained feature (nozzles), is there any delay in flame propagation at high speed operating conditions.

Reviewer 4:

The reviewer reported that nice accomplishments in demonstrating the single cylinder and multi-cylinder engine performance improvements. The optical engine data was a nice addition to the metal engine data. It was not clear to the reviewer what criteria were being used for acceptable indicated mean effective pressure (IMEP coefficient of variance (COV) and the slides indicate that the variation was minimal.

Reviewer 5:

The reviewer commented that there were interesting results regarding optimization of the TJI design details. Vehicle FE results need to consider the lean aftertreatment impact on fuel consumption because the NO_x are not low enough to avoid aftertreatment.

Reviewer 6:

The reviewer indicated that there was a significant level of work and analysis demonstrated with data from CFD and dyno testing results. Strong effort results in a nozzle design and discussion of tradeoffs and final design balanced between low speed and high power nozzle requirements. The reviewer added that the project team reported with data that indicated the peak thermal efficiency target has been met. The trade-off design results were also very good at above 40% thermal efficiency over a wide range of BMEP and lambda. The reviewer also said that the project accomplishments can be rated as excellent/outstanding once data is available showing verbally discussed emission results (engine out brake specific HC, CO reported comparable to baseline engine and approximately 40-70% lower NO_x @ lambda=2) with engine out exhaust emission temperatures at ~300°C). Drive cycle FE benefit which was not yet completed/ presented. The reviewer also indicated that clarification was provided that the combustion system is not plug-and-play and that valve train, piston, combustion chamber design is specific to the technology with some data presented in SAE 2015papers.

Reviewer 7:

The reviewer stated that it does not appear that the 45% BTE goal will be met. It also is not entirely clear how boosting and emissions control systems will be modelled adequately to predict drive-cycle FE.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer observed that there was good collaboration, use of knowledgeable industry advice, and subcontractors such as Ford, Delphi and Spectral Energies. There was excellent to outstanding collaboration through specific third-party confirmation of testing or analysis toward other applications such as NG/diesel pilot through an OEM, Tier 1 supplier, university or national laboratory.

Reviewer 2:

The reviewer said two subcontractors and vague comments about unspecified university contacts, not really exciting.

Reviewer 3:

The reviewer said that collaborations were limited to subcontractors.

Reviewer 4:

The reviewer commented that while there appears to be much collaboration with industrial partners, little use of the government laboratories seems in evidence. The reviewer would have thought that some optical engine tests with the TJI system might have proven useful. Also, the role of the various universities alluded to in the presentation should be more clearly delineated.

Reviewer 5:

The reviewer thought better coordination with Ford would be helpful with respect to establishing the hardware and FE implications of lean-operation emissions control systems.

Reviewer 6:

The reviewer stated that universities (not named in the presentation) were cited during the question and answer session. The reviewer suggested please include this in the presentation for future Annual Merit Reviews. The reviewer added that it was not clear what the role of the optical engine test lab (Spectral Energies) was in the project. The reviewer asked if this partner contributed expertise, or just provide data for Mahle interpretation. While the value in the optical data was apparent, it is difficult to evaluate their contributions.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer commented that the project team had a good plan to execute final project activities; MCE testing, mini-map generation, vehicle drive-cycle FE analysis, and system-level analysis of TJI operating strategy across the engine map. Excellent to outstanding is to also report emission benefit and potential aftertreatment approaches and savings and to consider pilot design and control methodologies on other critical applications such as dual fuel or dedicated natural gas.

Reviewer 2:
The reviewer reported that future work showed a good extension of present study. After generating engine maps and vehicle system drive-cycle analysis, it would be interesting to see the overall cost reduction analysis, including the TJI system, after-treatment system and operating cost.

Reviewer 3:
The reviewer said that the remaining steps are well-planned, although few key items (like emissions) are not in scope of project.

Reviewer 4:
The reviewer said the future plans look sound.

Reviewer 5:
The reviewer would really like a track of NO_x emissions with the optimization

Reviewer 6:
The reviewer said the project has ended.

Reviewer 7:
The reviewer stated that this is a project where it was not clear if the concept would work or not, and would not be pursued by industry because of this risk. Therefore, it is appropriate for DOE to invest in projects such as this.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer said that ultra-lean gasoline is a great goal. It will make a difference with petroleum displacement for passenger vehicles as long as it can meet the emission standards.

Reviewer 2:
The reviewer commented that this project used pure gasoline as the studied fuel, good FE was achieved as indicated in the presentation. The TJI system could also be used on a NG engine, bio-fuel engine or other future engine types, which supports the overall DOE objectives of petroleum displacement.

Reviewer 3:
The reviewer reported that the novel high-efficiency system appears suitable for widespread use.

Reviewer 4:
The reviewer said that drive cycle target FE improvement of 30% can make significant impact on the LD fleet as the technology could potentially be made available medium term on new vehicles. TJI could be enabling technology for improved dedicated NG vehicles and diesel pilot NG vehicles.

Reviewer 5:

The reviewer stated that multi-cylinder engine results show promising efficiency results.

Reviewer 6:

The reviewer said improved efficiency for reduced petroleum consumption.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that more resources would enable more complete final demonstration.

Reviewer 2:

The reviewer remarked that this was an excellent project and technology approach. The project is ending in 2015, and the technology agnostic FOA allows significant flexibility to look across industries and evaluate promising technologies.

Reviewer 3:

The reviewer said that resources appear sufficient.

Reviewer 4:

The reviewer commented that Tier 3 Bin 30 emissions control should have been included as part of this work but it was outside the scope of funded work.

Development of Radio Frequency Diesel Particulate Filter Sensor and Controls for Advanced Low-Pressure Drop Systems to Reduce Engine Fuel Consumption: Alexander Sappok (Filter Sensing Technologies, Inc.) - ace089

Presenter

Alexander Sappok, Filter Sensing Technologies, Inc.

Reviewer Sample Size

A total of five reviewers evaluated this project.

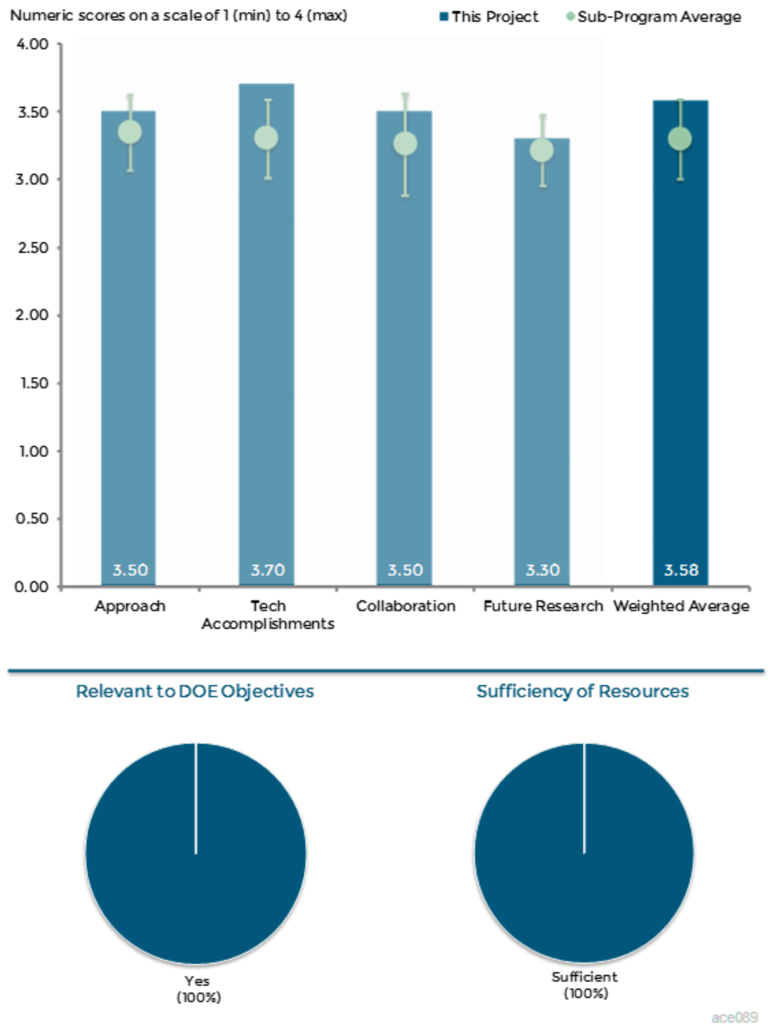

Figure 4-39 Development of Radio Frequency Diesel Particulate Filter Sensor and Controls for Advanced Low-Pressure Drop Systems to Reduce Engine Fuel Consumption: Alexander Sappok (Filter Sensing Technologies, Inc.) – Advanced Combustion Engines

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer remarked that the use of the radio frequency (RF) signal to understand soot load is great. The usefulness of this data could be useful not only to trigger and end regeneration, but also for some level of OBD on engine out conditions. The reviewer added that the presenter stated this technology is not applicable to the most popular soot filter material, silicon carbide (SiC), which is rather disappointing in one sense. If this becomes a commercial product it could be a boom for enabling less costly cordierite material, but at the same time, this material is not as robust.

Reviewer 2:

The reviewer observed that this project is well thought out and technically sounds. RF sensors seem to provide more information on soot loading than the pressure drop signal typically used in production vehicles. The reviewer said that its capability of distinguishing ash from soot is a big plus. The capability of identify uneven soot distribution in the filter is also very significant. The reviewer added that as the method has been presented, the capability of quantifying ash loading and uneven soot load on filters has not been utilized.

Reviewer 3:

The reviewer stated that determining the optimum regeneration time and duration in particulate filters given the standard pressure difference approach (corresponding to matter accumulation) has been a challenge for after-treatment manufacturers in terms of accuracy, efficiency and durability. The authors' methodology of developing a patented radio frequency RF-DPF particulate filter sensor to directly measure soot and ash levels and to control in real-time the after-treatment system operation based on those measurements is innovative and effective, enhancing the DPF-related fuel consumption and durability. The reviewer added that these critical barriers are sharply focused on and addressed in their approach, as presented in Slides 5 and 6, which shows multiple technical steps from research stage to production and commercialization.

Reviewer 4:

The reviewer said that this is a very novel sensing approach that looks like it has potential to improve controls and reduce fuel consumption.

Reviewer 5:

The reviewer commented that the approach was novel, well executed approach to DPF monitoring, OBD and active regeneration.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer commented that there are obviously demonstrated great technical achievements using the proposed RF-DPF sensor versus the pressure difference approach: accuracy in soot measurement during DPF loading and regeneration; reduction in regeneration time and frequency by immediately stopping the HC dosing once oxidation is complete; multi-function (soot and ash) design concept within chip set dimensions; superior sensitivity regeneration for biofuels; additional option of being used as a fast soot sensor for advanced controls; soot load level detection at idle; accurate measurement of ash load over time, invariably of ash deposits; after-treatment-related fuel savings of up to 3%. The reviewer added that the functional principle (see Slides 23 and 24) of measured change in resonant frequency modes using dielectric properties of contaminants (for example, soot) versus clean filter can be universally applied, regardless of DPF geometry, materials, temperature that is easy zeroing, and also reliable and suitable for on-board control and diagnostics. The reviewer also stated that even though the RF-DPF sensor clearly shows superior performance in many aspects, reviewer did not find a representation of overall system cost reduction. Any innovation, regardless of how technically superior is to the current production baseline, may turn away the manufacturers from adopting it if it is not economically advantageous (less expensive), because customers may not be willing to pay more. The reviewer said that perhaps a basic representation showing obvious financial gain would help.

Reviewer 2:

The reviewer stated that there were very clear results that show the improvement in sensing accuracy compared to the incumbent delta pressure (P) sensor. The fuel savings are significant in reducing wasted regeneration fuel and improving the accuracy of a regeneration event with real time feedback. The reviewer added that the correlation to an AVL micro soot sensor is an incredible result.

Reviewer 3:

The reviewer reported that significant progress has been made with sensor related development, integration and testing. Demonstration of fuel saving (DOE goal) is far more convincing than previous year. The reviewer added that testing included both LD and HD engines helps to expand the potential field of application. Demonstrations of fast sensor response, accuracy and durability are significant accomplishments.

Reviewer 4:

The reviewer said that everything shown so far has been very encouraging. It will be much more interesting to see data that shows the ability to decipher mal-distribution of soot. Also, the reviewer stated it seems there should be an inclusion of contaminants such as heavily loading the soot with HC. For example, when a vehicle idles in cold environments overnight, soot and HC can accumulate in the soot filter. The reviewer asked how the sensing technology responds. Also, the reviewer asked do water and sulfur affect the signal accuracy.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer indicated that collaboration and coordination with industry partners, a national laboratory, city fleet and/or subcontractors has been excellent.

Reviewer 2:

The reviewer stated very good coordination with national laboratories and Corning.

Reviewer 3:

The reviewer said that it is good that there is a fleet user to put miles and heat cycles on the sensors to test the long term stability and durability of the sensor.

Reviewer 4:

The reviewer remarked that there is a close, appropriate collaboration with other institutions. Slide 7 demonstrates an effective coordination with multiple technical partners regarding sensor design, benchmarking, materials selection, controls development and on-road fleet testing.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer remarked that it seems that the RF-DPF sensor withstood the harsh, unfriendly testing and calibration actual exhaust gas conditions, where damaging effects, such as temperature spikes during active regenerations or other harmful gases may have premature deteriorating effects. Filter Sensing Technologies, Inc. is already advertising this RF-DPF sensor on their website and offer to have it tested by other engine manufacturers. The reviewer added that it will be very interesting to hear feedback after actual road mileage, long-term testing conditions. Of ultimate but not least consideration should be the commercial/manufacturing plans towards proving an actual cost gain while using the RF-DPF sensor.

Reviewer 2:

The reviewer commented that the proposed future work is sound as the project team focuses on evaluation of optimized calibrations and controls to quantify performance relative to baseline (the delta P + Model) in a wide range of engine and vehicle applications.

Reviewer 3:

The reviewer reported that the presenter explained that the future work will include some purposeful mal-distribution testing. Testing the mal-distribution could really prove the worth of the technology because there have been so many field issues with partial regenerations, multiple events, that eventually lead to failures. Also, the reviewer said that it would be good to see if this technology can find failed parts that would be better than downstream soot sensors for OBD purposes.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer commented that any reduction in fuel consumption, including these demonstrated 1.5 to 3% after-treatment-related fuel savings, supports the overall DOE objectives of petroleum displacement.

Reviewer 2:

The reviewer said that the results show a direct impact on reducing fuel consumption to regenerate DPF.

Reviewer 3:

The reviewer reported that if successful, the technology would results in fuel saving that would support DOE objectives of petroleum displacement.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented that resources appear adequate.

Reviewer 2:

The reviewer said that funding seems to be adequate for the remaining tasks.

High-Dilution Stoichiometric Gasoline Direct-Injection (SGDI) Combustion Control Development: Brian Kaul (Oak Ridge National Laboratory) - ace090

Presenter

Brian Kaul, Oak Ridge National Laboratory.

Reviewer Sample Size

A total of seven reviewers evaluated this project.

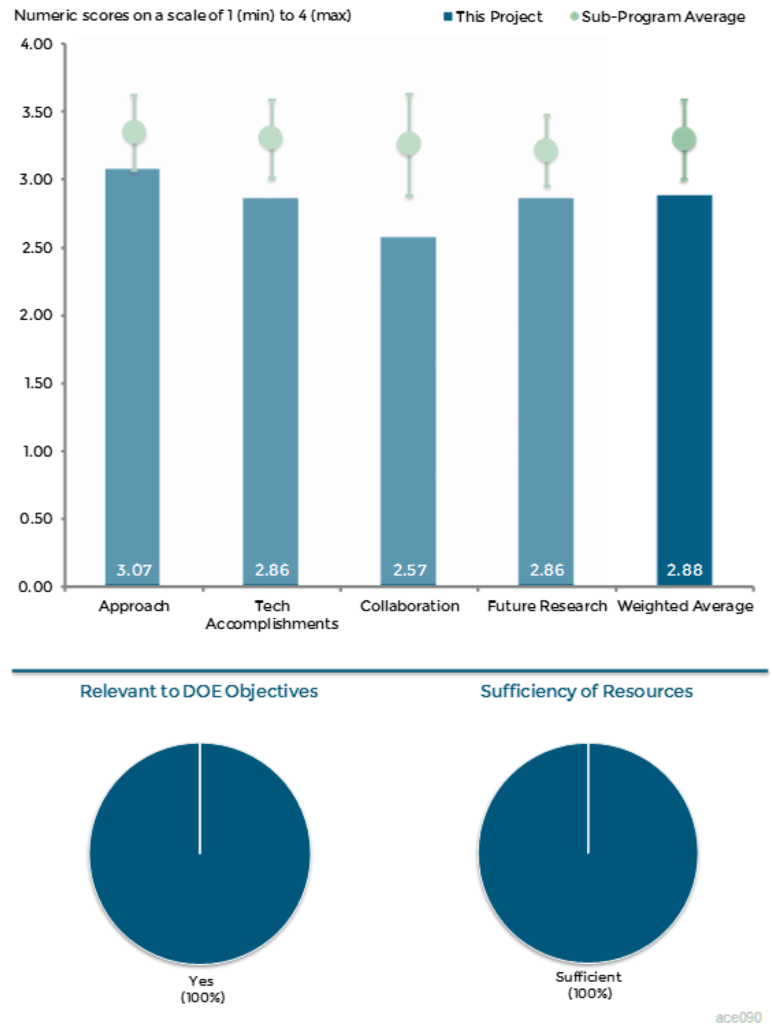

Figure 4-40 High-Dilution Stoichiometric Gasoline Direct-Injection (SGDI) Combustion Control Development: Brian Kaul (Oak Ridge National Laboratory) – Advanced Combustion Engines

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer reported that the project team had a very interesting approach towards combustion control and near edge stable operation. This research is important for both controls and improving misfire diagnostics. The reviewer added that the project had a cost effective and real time combustion analysis with cylinder pressure on-board a production vehicle will be challenging. Hence, this research and development effort should continue for both the strategy itself and its implementation.

Reviewer 2:

The reviewer commented that the use of tools to reduce cycle-to-cycle variation and validate on an engine is a good approach.

Reviewer 3:

The reviewer stated that the project is developing controls using deterministic behavior to reduce cycle combustion variability. A symbol-sequence statistics analysis was used, where the method describes a partition data and identification of sequences. The reviewer added that the objective seeks to extend the SI dilution limit though it may appear to be more of an enabler. The approach does not focus on the physics or new hardware of the engine platform but rather data analysis. The reviewer also said that the approach is believed to be marginally effective.

Reviewer 4:

The reviewer pointed out that this project very effectively addresses need for combustion stability control to enable high efficiency at part-load, highly-diluted GDI engine operation regime. For FY 2014-15, the project has adopted a solid approach: characterize cyclic variability in high EGR operation; assess symbol-sequence statistics analysis; develop next-cycle control scheme; implement next-cycle control scheme on General Motors LNF 2.0 liter turbocharged GDI engine and assess its efficacy.

Reviewer 5:

The reviewer noted that it would be good to quantify the potential opportunity to improve engine efficiency with this work. The reviewer suspected that it is fairly small.

Reviewer 6:

The reviewer stated that this project enables engines to operate at the dilute limit. High dilution engines are one pathway to high efficiency engines.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer said that the good progress with accomplishments include: showed that the approach of symbol sequence analysis is effective even with real world poor quality data (relative to the lab environment), improved understanding of the cycle-to-cycle dynamics needed to develop effective control structure, discovery that a restrike spark can help reduce misfire events, although retarding the restrike further can be counter-productive resulting in increased COV and misfires.

Reviewer 2:

The reviewer commented that the work is being carried out on a 4-cylinder GDI engine. High fidelity data was used and later down-sampled for possible production implementation. The authors may note that down sampling is likely not needed as there are production like controllers developed that can retain the high fidelity, for example, with 0.5 degree crank resolution). The reviewer added that the work included a multiple spark strategy as a control over cyclical dynamics. The effects of cycle-to-cycle perturbations of ignition and fuel quantity were examined. Also, the reviewer said the work identified a symbol sequence to identify event signatures that may be dominated by for example internal or external EGR. The approach is seen as an enabler to operating at high-dilute regions. Significant work is required to verify and provide evidence that this is the case.

Reviewer 3:

The reviewer said that the above approach has enhanced and quantified fundamental understanding of cycle-to-cycle dynamics and led to a very interesting symbol-sequence based control concept for a GDI engine (Slides 8-16).

Reviewer 4:

The reviewer commented that Progress has been made, but more focus should be on demonstrating the benefit of the specific control algorithm technique. The reviewer said that the big question is if nonlinear dynamics, information theory, and symbol sequence statistical analysis show promise to enable engines to operate at their dilute limit, and that this should be answered as soon as possible. The reviewer added that it seems like the project is getting defocused by going down some trails that are of minor importance, or not high priority.

Reviewer 5:

The reviewer said that it is important to understand if the technique will work in a production engine controller environment and sensor set. It is good to see technique is robust to lower quality data.

Reviewer 6:

The reviewer indicated that progress made towards symbol sequence analysis to understand cycle to cycle variations, and demonstrating the methodology holds merit even with real life data with low quality.

Reviewer 7:

The reviewer indicated that there does not seem to be a lot of progress since the last AMR. The data quality analysis is interesting, but not relevant if the whole approach does not work. The reviewer added that it is more important to prove out the concept with high quality data and then later go back and consider lower quality data.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer commented that the collaborations appear limited to two equipment/controls suppliers

Reviewer 2:

The reviewer reported that the project is tied to the ORNL-Cummins CRADA, which appears very valuable. The reviewer added that little information is provided by the contributions of the other partners such as National Instruments, Bosch or Argonne National Laboratory. This could be better described.

Reviewer 3:

The reviewer stated that the team has brought in industry and laboratory partners and is seeking additional industry assistance in the controls area.

Reviewer 4:

The reviewer pointed out that collaborations are minimal and need to include OEM control teams to really have an impact.

Reviewer 5:

The reviewer indicated that extensive collaboration with expert controls personnel at an OEM is necessary to make this project relevant and useful. It is recommended that this collaboration be sought.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer said that having characterized the problem and the levers that affect it, the next step is to build a control mechanism to overcome the instability and reduce CCV. This will be challenging, but the team has put a lot of good work in so far, so the path is reasonably well laid out.

Reviewer 2:

The reviewer indicated that the online model based control using this methodology, also in transient operation, is a future research to look forward to.

Reviewer 3:

The reviewer commented that plans seem to be supported by the U.S. DRIVE ACEC Technical Team and to build on progress and advance toward ultimate project goals.

Reviewer 4:

The reviewer stated that the work in 2016 to 2017 was described, this includes the development or models and control strategies. The work will be challenging based on the results to date but the reviewer looks forward to seeing how it progresses.

Reviewer 5:

The reviewer pointed out that it is not clear what the approach will be for next-cycle control.

Reviewer 6:

The reviewer reported that the primary focus should be on demonstrating the ability of the control algorithm to operate safely at the dilute limit.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer said that the project team improved fundamental understanding and development of improved control systems to reduce cyclic variability and extend the SI lean dilution limits will help to assess feasibility of this approach to achieve DOE objectives.

Reviewer 2:

The review reported that the control development work is necessary for implementation of advanced combustion techniques. This particular project is tied to other current programs. Any progress made here will be applicable across a wide horizon.

Reviewer 3:

The reviewer stated that a practical control strategy would allow high-dilution EGR operation of GDI engines, increasing their efficiency and reducing petroleum consumption.

Reviewer 4:

The reviewer commented that the active combustion control is a very important research topic for advancing engine efficiency and non-traditional combustion regimes.

Reviewer 5:

The reviewer observed that this project does not extend the dilute limit of an engine. It simply enables the engine to operate at the dilute limit.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that it is actually surprising what has been done with the budget so far, but the progress is so good, have little doubt the team can continue to make progress with the requested resources.

Intake Air Oxygen Sensor: Claus Schnabel (Robert Bosch) - ace091

Presenter

Claus Schnabel, Robert Bosch.

Reviewer Sample Size

A total of five reviewers evaluated this project.

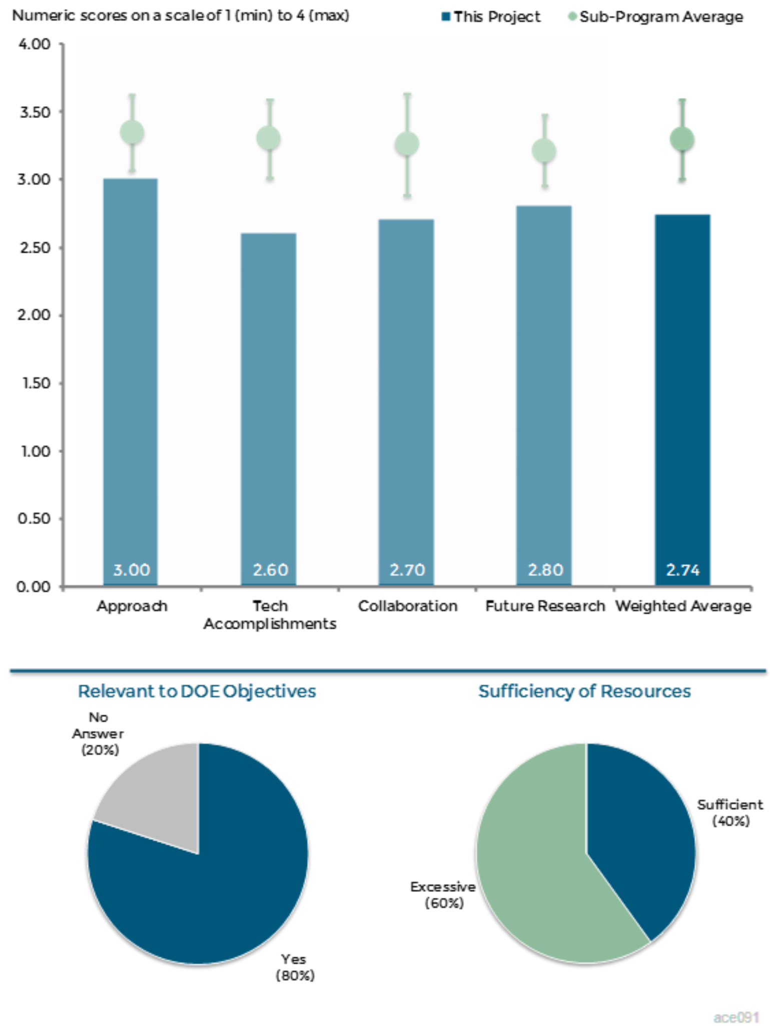

Figure 4-41 Intake Air Oxygen Sensor: Claus Schnabel (Robert Bosch) – Advanced Combustion Engines

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commented that the approach was excellent, if fairly typical, for a development process, involving a close coupling between physical experimentation and computational simulation.

Reviewer 2:

The reviewer said the work is certainly sound. The reviewer could understand why intake air oxygen (IAO_2) is needed for cEGR monitoring and control. It is kind of hard to get excited about this because it appears to be based largely on an off-the-shelf wide-band O_2 sensor.

Reviewer 3:

The reviewer stated that Bosch has a good basis for understanding the O_2 sensing needs and how to make sensors that work reliably. Starting with the exhaust O_2 sensor and making the needed modifications is the best way to get the most out of the resources.

Reviewer 4:

The reviewer reported that this project is well designed in terms of oxygen sensor development, installation on the engine; however, the investigators failed to address the concern as what is necessary accuracy of the sensor required for cERG control. Accuracy target of plus/minus 2% deltaO_2/O_2 is quite high. It is not clear if this requirement came from cEGR partners as an integrated part of overall control strategy.

Reviewer 5:

The reviewer reported that the approach of carrying over a production sensor element is not very cutting-edge. The reviewer suggested investigating improved sensor elements. This project looks like product development. The reviewer added that NGK published an SAE paper on using an intake O_2 sensor to control EGR in 1988.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer commented that overall, the progress and accomplishments have been good. It is mentioned that the engine simulation to demonstrate sensor benefits has been completed as a milestone, but the presentation does not show any results. Also, the reviewer said some of the technical accomplishments, such as Identified sensor location, seem to be very incremental. It would have been helpful to include comments from previous year's presentation and actions taken to incorporate their suggestions into this year's effort.

Reviewer 2:

The reviewer noted that Bosch has plenty of expertise in O_2 sensors, which has been well applied in this project. There were technical accomplishments with regards to the sensor fit well with the project and DOE goals.

Reviewer 3:

The reviewer observed that it seemed as though the team has tackled the really difficult tasks and have a means to compensate for the changing environmental conditions. The reviewer would have expected the work to be done much in parallel to nearly all tasks, and would have expected to see much more compensation work having been done as the first order to this project (pressure and Lambda-like compensation routines). Also, the reviewer thought a big open question is how well this would work on diesel. As much money that has been spent and no data for diesel is a very big hole in the entire plan, diesel is always lean, and it would be expected, diesel might be the first adopter for such a sensor. The reviewer asked how this could not have been in the very front end of the project.

Reviewer 4:

The reviewer reported that progress is slow for such an expensive project. Cross sensitivity to hydrocarbons in purge vapors or crankcase vapors could be a significant impediment to implementation.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted that the collaboration with Clemson University and ORNL is good, it might be useful to have some engine makers directly engaged to get their input as part of the program.

Reviewer 2:

The reviewer said that there is no mention of input from potential customers. The reviewer suggested that the project team collaborate with an OEM to ensure that customer requirements are met.

Reviewer 3:

The reviewer stated that collaboration and coordination with partners seems to be lacking or not shown. Hopefully, this situation will change for the future tasks.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer observed that the future directions are sound and logical. Bosch is well qualified to take on the sensor development. The reviewer added that the demonstration of sensing benefit require close collaboration with cEGR partners. It should occur during this phase of the project.

Reviewer 2:

The reviewer commented that the projected tests to demonstrate the impact on efficiency and emissions performance of this sensor (presumably in comparison to differential pressure sensors) for cEGR application in engine tests will be crucial to ultimately judging whether the extra cost is justified. The investigators are encouraged to make this a priority.

Reviewer 3:

The reviewer suggested that a demonstration of the benefits of IAO_2 sensing is the most promising, but the reviewer also believed that would be best demonstrated if there were an engine OEM involved. The reviewer noted the work being done does not include a car manufacturer, as it would seem the OEM would be the ones to specify the use of the part.

Reviewer 4:

The reviewer reported that future plans are very broad and lack precision to assess probability of success.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer reported that this is relatively accurate information on intake oxygen could potentially improve cEGR control strategy thus improve the FE which supports the DOE objective.

Reviewer 2:

The reviewer stated that the technology promises to aid efficiency gains which will aid in reducing petroleum consumption.

Reviewer 3:

The reviewer said that the project is an enabler to implement cooled EGR, the intake O_2 sensor could lead to reduced fuel consumption.

Reviewer 4:

The reviewer remarked that this project is really focused on emission control, and if this device is able to improve emission control on lean burn engines, then it will help achieve DOE reduced oil dependency.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said that the funding seems to be adequate for the remaining tasks.

Reviewer 2:

The reviewer said that resources seem adequate.

Reviewer 3:

The reviewer stated that it is not clear why DOE is paying for product development at Bosch.

Reviewer 4:

The reviewer commented that Bosch is a world leader in the development and sales of O_2 sensors. This sensor would likely have been fully developed and commercialized entirely without funding from DOE because there is an OE need for cEGR systems.

Reviewer 5:

The reviewer reported that the work of testing for water intrusion, salt spray and the like, seemed to be excessive for proving out an intake O_2 sensor that is a derivative product. This is the sort of work that would be done in a path to production, which is not what should be done on the DOE's money, but rather on the supplier's money. The reviewer added that in total, it is understandable the high cost of development, but when considering this derivative product program ran for $4.5 million versus some national laboratories that ran sensor programs that were $1 million for something brand new, it seems excessive.

High-Efficiency VCR Engine with Variable Valve Actuation and New Supercharging Technology: Charles Mendler (Envera LLC) - ace092

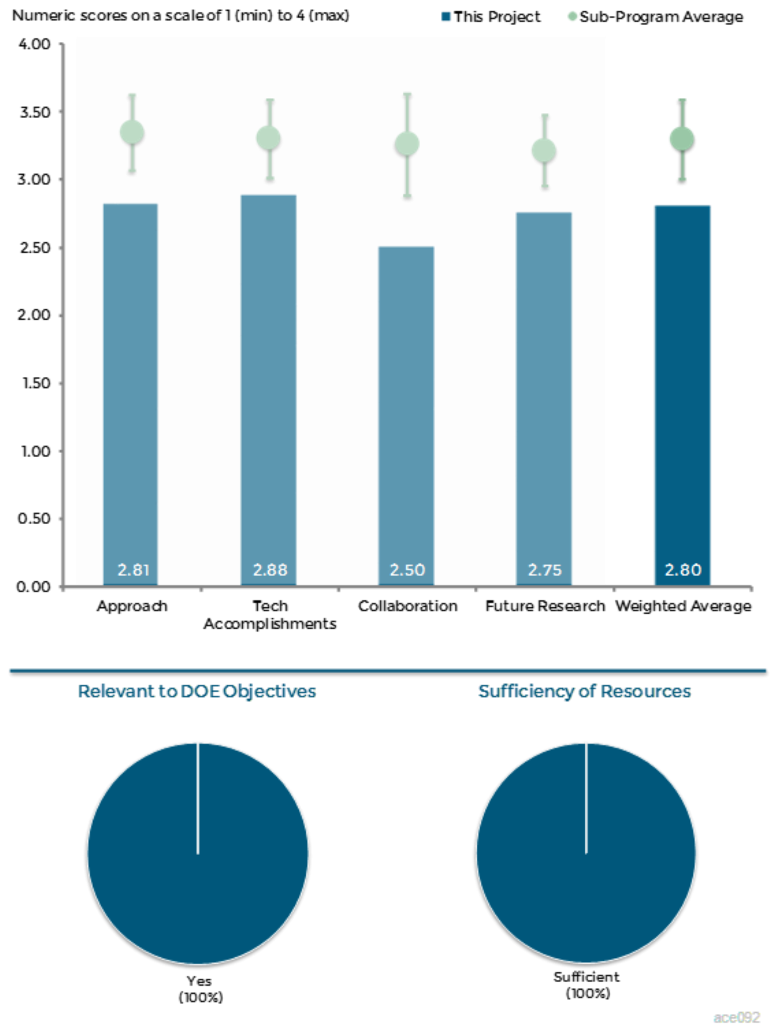

Figure 4-42 High-Efficiency VCR Engine with Variable Valve Actuation and New Supercharging Technology: Charles Mendler (Envera LLC) – Advanced Combustion Engines

Presenter

Charles Mendler, Envera LLC.

Reviewer Sample Size

A total of eight reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated there was a project re-scope from 2014 AMR vehicle and dyno scope to a dyno engine only development with simulated vehicle results. This is an excellent adjustment to successfully achieve technical proof of concept more quickly and is better aligned with current budget. The reviewer added that a successful result from PI review of state of the art is new mechanical design for VCR device, which has simpler implementation on the dyno and more desirable packaging envelope for production application than prior eccentric crankshaft device. Current device could potentially retain much of production tooling and reduce investment upon successful proof of concept as majority of base engine geometry and many production components can be maintained or modified slightly for variable compression ratio implementation reducing time and risk. The reviewer stated that the GT-Power modeling of best case performance with Eaton analysis and re-design of two step lost motion cam device is also very good approach. Techno economic value analysis effort outstanding change to scope.

Reviewer 2:

The reviewer observed that the approach is rather unique in this program by incorporating both VCR and variable valve timing. The approach allows to application of the Atkinson cycle in a unique way to promote high engine efficiency. The reviewer added that the project includes supercharging as a means to hit very high power output.

Reviewer 3:

The reviewer noted that this appears to be a novel variable compression ratio (VCR) approach. The reviewer thought considerable work will be necessary to characterize both the durability and NVH characteristics of this engine design. It is not clear to this reviewer why a mechanical supercharger was chosen instead of an exhaust-driven turbocharger or a combined turbocharger and e-charger, particularly when considering the CAFE target of 40% improvement.

Reviewer 4:

The reviewer commented that this project was a very hardware oriented program looking at VCR with VVA and higher PR supercharger. As VCR is in itself not completely new concept, this project appears to be evolutionary than revolutionary, but some significant results have been achieved. The reviewer added that it appears to be lagging a little behind a linear timeline from the time and money spent to date. As a lot of what is shown is feasibility study, there is a lot that has yet to happen to get to the all up hardware engine testing stage. Also, the reviewer said there seems to be very little analysis work going on to support this project, some GT-Power and finite element analysis (FEA) results are shown or mentioned. It would be good to be doing some CFD particularly in cylinder to help support claims like best part load efficiency occurred with an internal EGR dilution value of only 12%. The reviewer stated that this finding indicates that the Atkinson cycle with moderate dilution values may provide an easier pathway to attaching high efficiency than low temperature combustion and extreme-dilution approach. This may be asking too much of GT-Power to conclusively demonstrate.

Reviewer 5:

The reviewer stated that there are many technologies stacked together here. The VCR mechanism is probably the most difficult to achieve, and yet it may not be the largest contributor to FE gains when compared to the boosting and VVA Atkinson features. The reviewer added that needs further information to justify the emphasis on the VCR. Also, it is concerning that there appears to be a shift to a different design of VCR, very similar to the Toyota approach. The statement to upgrade to the Toyota VCR is a peculiar mid-project course correction. The reviewer stated that presentation mentions first public showing but did not list patent status, the reviewer may have missed it. There is positive-looking development is the Eaton supercharger with integrated charge cooling.

Reviewer 6:

The reviewer reported that all VCR systems are mechanically complex, and the proposed concepts are no different. The approach to use production GM cylinder head is a good idea to avoid the difficult task of designing and manufacturing a cylinder head.

Reviewer 7:

The reviewer is skeptical of this approach, the mechanical design demands can be great and durability may be a problem; that said, it is appropriate to try. That is the mission of the DOE. The reviewer added that eliminating the in-vehicle demo is probably good. This is a daunting mechanical study.

Reviewer 8:

The reviewer observed that details of the approach and process that will be used to claim 40% improvement in FE were not provided. PCP may be exceeding design limits of the engine being modified, so claims of high power density may not be a fair apples to apples. The reviewer added that the temperatures in-cylinder are very high, but not quoted (GT-Power modeling).

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer observed that the GT power modeling that was completed and presented are a very good accomplishment for the project. Some caution should be exercised in the use of the modeling results, because there is no engine data yet to validate those modeling results.

Reviewer 2:
The reviewer commented that a redesign of a VCR device to linear block movement is a solid accomplishment from eccentric crankshaft device improving both proof of concept test efficiency and potential production possibilities. GT Power modeling of best case performance with Eaton analysis and re-design of two step lost motion cam device is also good approach.

Reviewer 3:
The reviewer commented that as noted above, some interesting results have been shown, but the tougher work of hardware demonstration is still ahead. The team needs to seriously consider adding more tools and resources to aid in achieving the ultimate goals of the project.

Reviewer 4:
The reviewer was expecting to see design details for the VCR mechanism, not an entirely new concept; however, the new concept looks like a much more promising approach. Loading of the eccentric mechanism will need to be carefully considered because cylinder pressure loads act directly on the mechanism. The reviewer explained that the comment regarding 12% internal dilution on Slide 9 is not surprising as this is not just a function of dilution but also of the impact of valve events on pumping losses. The addition of external dilution would improve efficiency further assuming the combustion system has adequate dilution tolerance; however, as this project is focused on VCR, this is an additional complication best deferred to follow-on work.

Reviewer 5:
The reviewer reported that comparing the 2014 and 2015 schedule suggests some major changes and delays have occurred. There was approximately a year shift in milestones. The reviewer said that the consideration to go to a substantially different VCR design indicates issues with original approach which was the basis for award. The major positive accomplishment was the Eaton supercharger development/innovation.

Reviewer 6:
The reviewer observed that much of this is mechanical design and modeling.

Reviewer 7:
The reviewer stated that the presentation needs to be better organized to clearly communicate the engine simulation and its projections. This should include a complete description of the engine architecture or a reference to it. The reviewer added that the program supercharging work is interesting, especially the new concept provided. The addition of this work is rather separate from what appears to be the main effort. The reviewer warned that the authors should not allow this work to compromise the VCR-VVA work.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer remarked that there was excellent collaboration with Tier 1 valve train supplier Eaton and subcontractor for GT Power model to re-design valve train. Good efforts to front load controls effort with industry suppliers and to initiate some coordinated feedback from vehicle OEMs.

Reviewer 2:
The reviewer reported that the program has a strong relationship with Eaton. The program should strive to enlist a similar OEM partner over the course of the next year.

Reviewer 3:
The reviewer observed that the coordination with Eaton appears to be good. This project would benefit from auto industry partners. The reviewer added that development of the combustion system, coordination of the combustion system design with the VCR system, and engine calibration across a large design space would benefit from further partnership with the DOE national laboratories, one of the major auto companies, or a major engineering design firm such as AVL, FEV, Ricardo, and IAV.

Reviewer 4:
The reviewer stated that there are strong contributions from Eaton.

Reviewer 5:
The reviewer commented that the collaboration with Eaton is encouraging. This reviewer also pointed out that "sighting" on Slide 23 should probably be "citing."

Reviewer 6:
The reviewer said that in describing collaboration themselves, the researchers noted that the interest from the OEs, component manufacturers, and other R&D organizations is welcomed. The reviewer could not agree more, compared to the 20 or so other projects being reviewed by the reviewer this year, this has perhaps the weakest collaboration ties to laboratories, universities, and engine makers. More work to cultivate such partnerships is definitely recommended.

Reviewer 7:
The reviewer noted that collaboration with an engineering design house could provide a critical assessment of the mechanical design and integrity of the engine.

Reviewer 8:
The reviewer explained that the project could benefit from some academic involvement for more sophisticated simulation of combustion effects from the added supercharging along with the Atkinson cycle combustion.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer reported that the project is focused on the mechanicals, yes. Modeling has limited value if the mechanicals cannot deliver.

Reviewer 2:
The reviewer said that the short term (next year or so) of work is described, but not much in the out years where things are bound to get very interesting (engine builds, testing, etc.). Again the team is suggested to get more outside partners involved, particularly if the team can bring analysis capability onboard.

Reviewer 3:
The reviewer observed that the project team revised variable compression device design using variant of production Eaton supported valve train pathway to design Atkinson/ Otto cycle engine concept, implemented on dyno, and use dyno data to project vehicle results is a strong method to overcome technical and commercial barriers. Proposed future research and partners are currently very good and can be improved with definition of experienced controls development method and /or partner(s) to possibly leverage hardware for multiple control strategy developments once hardware is available.

Reviewer 4:
The reviewer stated that the work is clearly indicated. This work should include a more complete description of the new VCR architecture and the challenges in its implementation.

Reviewer 5:
The reviewer said that the best part of path forward would be to validate the gains from the Eaton supercharger. If the down select of VCR method goes to VCR number two, the distinctiveness of the project will seem to diminish because number two is so close to a Toyota system.

Reviewer 6:
The reviewer noted that the plan looks okay. Please put emphasis on the hardware build and test results that are needed for the modeling validation.

Reviewer 7:
The reviewer commented that the future work needs to include mechanical design analysis of eccentric mechanism that raises and lowers cylinders and head.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer indicated that the project goal to develop and demonstrate a successful, cost effective, production feasible VCR device with potential to achieve 10-25% FE improvement while adding engine flexibility for alternate fuels, bi-fuels, and advanced combustion regimes clearly supports DOE objectives.

Reviewer 2:
The reviewer pointed out that improved FE always supports the petroleum displacement objectives.

Reviewer 3:
The reviewer said yes, the development of technologies such as VCR are important and so its application and integration into the powertrain.

Reviewer 4:
The reviewer commented that this technology should improve efficiency, reducing petroleum usage.

Reviewer 5:
The reviewer observed that variable compression is a proven way to improve light load engine efficiency.

Reviewer 6:
The reviewer noted that viable VCR concepts will provide improvements in fuel efficiency, although maybe not as much as claimed in this project (modeling 1-D results).

Reviewer 7:
The reviewer stated that as originally conceived, the project would result in an engine configuration (option) offering higher efficiency.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer said funding is probably sufficient. This seems to be pretty much a one-man operation and any limitation by the PI could derail the project.

Reviewer 2:
The reviewer suggested to rescale to dyno and controls development for initial proof of concept funded appropriately.

Reviewer 3:
The reviewer stated that it is hard to say, the program looks thin in some areas for what has to be done, the reviewer's organization would not consider going in so blind into a technology program like this, the reviewer's organization would be making much more extensive use of analytical tools to support our design concepts and decisions. Such work does require money, but it saves it (in time alone) down the line.

Lean Miller Cycle System Development for Light-Duty Vehicles: David Sczomak (General Motors) - ace093

Presenter

David Sczomak, General Motors.

Reviewer Sample Size

A total of six reviewers evaluated this project.

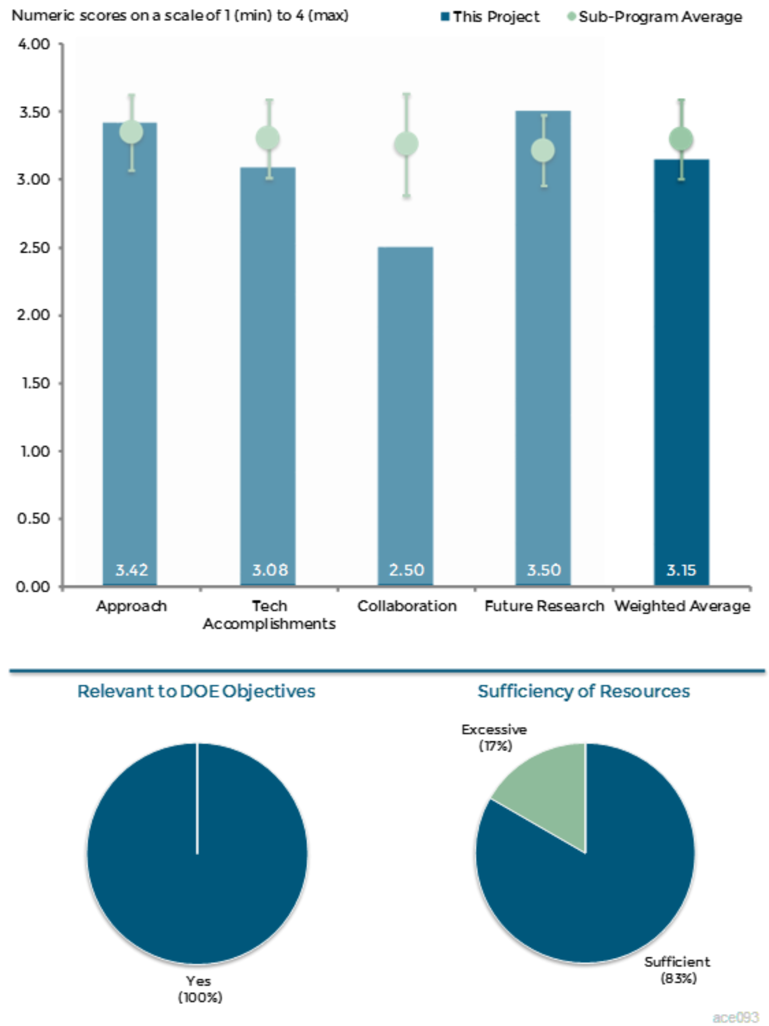

Figure 4-43 Lean Miller Cycle System Development for Light-Duty Vehicles: David Sczomak (General Motors) – Advanced Combustion Engines

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer noted that this new project has an excellent approach. The approach concentrates on high efficiency gasoline engine technology and will push the boundaries past existing state of the art with the Miller cycle and lean operation.

Reviewer 2:

The reviewer stated that while 35% FE improvement while meeting Tier 3 emissions is a challenging goal, an excellent approach with a detailed task plan was presented. A very good technical project plan with appropriate tasks, milestones and schedule was presented.

Reviewer 3:

The reviewer reported that lean burn in general is pushing it for the United States, and then downsized Miller cycle GDI will be a challenge. This is the kind of project that should be in these programs. The reviewer added that 25% fuel consumption (FC) improvements is big. The approach is classical with single cylinder engine (SCE), evaluation, MCE, vehicle. The reviewer also said it was good to farm out SCE to AVL, which has impressive experience in this realm.

Reviewer 4:

The reviewer said that some details of the approach came out in the Q&A that were not clear from the presentation, but insufficient detail was given to fully evaluate. This is early in the start of the project, and the team is still being assembled. The reviewer added that not all strategic partners/suppliers have been selected. AVL is being used for making single cylinder parts and testing of GM designs. The reviewer stated that without knowing the other strategic partners/collaborators, such as for the aftertreatment system, the soundness of the approach was difficult to evaluate.

Reviewer 5:

The reviewer commented that this project is still at a very early stage and there is sufficient time for course correction. It does not seem clear that the combination of lean-dilute combustion and passive/active SCR will be sufficient to achieve Tier 3 Bin 30 emissions. The reviewer explained that a lean-dilute approach will likely need some form of NO_x sorption to achieve the necessary cold-start NO_x control and lessons can be learned from use of this approach in ace061. Another, much simpler, approach would be dilute-stoichiometric using increased cEGR for dilution and conventional three-way catalyst control to achieve Bin 30. The reviewer suggested that there be some decision point partway through this project that could allow a course correction, if necessary, to assure that Bin 30 emissions are still within reach, similar to what occurred in ace065.

Reviewer 6:

The reviewer commented that this project concerns developing an ICE based on the Miller cycle. The PI believes this cycle has the capability to achieve DOE's target of a 35% improvement of engine efficiency. The approach seems to be to operate the Miller cycle to employ lean combustion. The reviewer added that the stated tasks include developing and demonstrating a vehicle, with testing of various cylinder heads to be done by AVL in a single cylinder engine. The Miller cycle has been known for decades (going back to the 1950s) and some manufacturers have commercialized engines based on it including Mazda, Subaru, etc. The presentation considered GM's effort to employing the Miller cycle in the context of the prior art. The reviewer said that it was not clear that a Miller cycle engine alone could facilitate achieving the targeted efficiency gain. Indeed, one of the presentation figures showed that an aggressive Miller cycle (aggressive was not defined) was projected to achieve an 18% improvement in efficiency. This is half of the target. The reviewer added that the other things that contribute to an efficiency improvement apparently are to come from elements that could be relevant to other parts of overall system and not specifically tied to developing a Miller cycle engine: 4% for advanced thermal management (not clear); 2% from friction/mass reduction. The reviewer asked what the specific strategy is and what the unique approach is here; 8% from downsizing; etc. In addition, the reviewer said the presentation was offered in vague terms with a long list of tasks, as if the audience already had a clear vision of what was needed to develop an engine based on the Miller cycle. Tasks like procure single cylinder hardware or multi-hole injection head design, or lean Miller development did not provide much information. Also, the reviewer commented that a large effort seemed to be associated with SCE testing of piston bowl designs. Curiously, no specific designs were shown, or how the overall system might be projected to respond to different designs. The reviewer asked if the piston bowl design is the key enabler to reaching the target. If so, the reviewer asked if the results of this effort could be used to develop a new piston bowl be applied to other engine concepts. The reviewer added that the CFD tool being employed was not clarified. The reviewer asked if it is KIVA, Converge, some other program. The reviewer also asked how will the codes be calibrated and assessed for accuracy. In addition, the reviewer asked what will be achieved with the simulations and what, specifically, do the PI's intend to do with simulation capabilities. Some 1-D modeling was mentioned but precisely what was to be modeled with such an approach was unclear.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer stated that the project management plan looks flexible and realistic. The scope and challenges are realistic. The reviewer said that expecting SCR+GPF is good for the plan. The project team can pull back if not needed. The reviewer added that thermal analyses seem aggressive, but give targets on what to work on for biggest bang.

Reviewer 2:

The reviewer said that as this is a new project, the technical accomplishments are in a state of development. The presentation did mention some computational efforts (1D and 3D modeling) and optimizing piston bowl design; however, details were not provided. The reviewer added that a lot of the effort seems to rely on SCE testing. The rationale for this was not clear from the presentation. The reviewer asked if there are there any concerns with extending results from a SCE to a MCE. The CFD work presented was interesting, but still hard to follow. It concerned a comparison between a CFD simulation (the code was not specified) of a spray calibration though the comparisons in the shown in one of the slides seemed mostly qualitatively correct in the CFD's ability to predict the spray pattern. The reviewer asked what would be done with this sort of capability (identify key features of the physics of the fuel injection... or ...analyze various piston bowls and spray shapes...) this should have been clarified.

Reviewer 3:

The reviewer commented that this project is a new start (only 5% complete) and therefore technical accomplishments are very limited (combustion modeling was initiated) and cannot be evaluated at this early stage.

Reviewer 4:

The reviewer indicated that no progress was reported, but to be fair, the slides were submitted just a few months after the project start.

Reviewer 5:

The reviewer thought that the approach to achieving 35% CAFE is fundamentally sound. The reviewer also thought some additional thought needs to be put into cold-start NO_x control.

Reviewer 6:

The reviewer stated that the project just beginning; so, not much to rank here. On track so far.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer said the project team has got a world-class participant with AVL. The reviewer suggested that the project needs to line up others. GM has access to many suppliers, so the reviewer is not concerned.

Reviewer 2:

The reviewer indicated that while GM is an engine and vehicle OEM and AVL was identified as a project partner for engine component fabrication and experimental testing, the project could benefit by involving a national laboratory or a leading research university with appropriate core capabilities to increase and share the technical knowledge in this area. The reviewer added that it was acknowledged that suppliers for various engine components might be engaged from a strategic standpoint it would likely be beneficial to have the complete team onboard from the project start.

Reviewer 3:

The reviewer noted that only one other institution was identified, which was AVL. It was also unclear whether there was a contributing partner, or a supplier, but it seemed that supplier was the more appropriate term. The reviewer observed that additional strategic suppliers will be named as the project comes into full swing. Until these suppliers and the manner in which they will be used for the project are given, the collaboration and coordination cannot be highly rated. The reviewer added that this needs to be firmed up for next year's review.

Reviewer 4:

The reviewer commented that there really does not seem to be any collaboration with other institutions. AVL is a part of the team; however, their role appears to be more of a subcontractor. The reviewer also reported that getting other partners onboard was mentioned in the presentation.

Reviewer 5:

The reviewer thought that AVL is a good partner but the reviewer would like to see more collaboration with either the national laboratories or academia.

Reviewer 6:

The reviewer stated that one collaborator listed is AVL. The reviewer asked is this the only one. The milestone list indicates many external supplier organizations, but none are specified. The reviewer said that on this basis, the team would seem to still be in a state of development. It is not clear how the budget was developed with this level of uncertainty of the project team, especially if some key element of the project was based on an external supplier that could not provide the required services for the appropriate costs. The reviewer recommended that future presentations should clearly outline the partners, what they specifically bring to the project, and if and what are the budget allocations to them.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that a very detailed task plan was presented with appropriate quarterly milestones and annual go/no-go decision points. The project plan and schedule are appropriate for the project of this size ($20 million over 5 years) and with an aggressive goal of 35% FE improvement while meeting Tier 3 emissions standards (can be very challenging as the emissions control systems of today likely will not be adequate to achieve the required emissions levels).

Reviewer 2:

The reviewer noted that the future plan looks sound and the pathway to reach 35% improvement in FE meets the objective. The reviewer looks forward to seeing a more detailed plan presented in the future years.

Reviewer 3:

The reviewer stated that the plan was laid out, now execute. The reviewer thought many will be watching this project. A 25% FE reduction seems quite aggressive for lean burn GDI. The project team has identified the tasks quite well.

Reviewer 4:

The reviewer said that at this stage, virtually all the work is future work, but the plans are solid.

Reviewer 5:

The reviewer said again, this project is just beginning. In presenting the tasks for future work, these should be framed in a way that provides logic to the next steps needed to achieving the targeted efficiency levels; much was unclear here.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer remarked that this will directly reduce petroleum via engine efficiency gains for gasoline engines if successful. The gasoline-dominant U.S. fleet means the relevance is high.

Reviewer 2:

The reviewer explained that efficiency improvements in LD powertrain (35% FE improvement target) result in lower fuel use and therefore a direct displacement of petroleum for passenger vehicles.

Reviewer 3:

The reviewer commented that 25% FE is certainly in line with DOE objectives. As a taxpayer, the reviewer likes these projects that push the envelope through established parties. The money is well spent.

Reviewer 4:

The reviewer stated that 35% improvement in FE for LD vehicles will reduce petroleum consumption in the transportation sector.

Reviewer 5:

The reviewer said that of course, any project that could achieve the targeted 35% efficiency gain would be considered relevant. For this project, there is not sufficient resolution in the question (yes or no' is too coarse) to answer. For the time being, the answer is presumably yes.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said that this is a high importance and visibility project due to the aggressive goal of fuel efficiency improvement (diesel-like efficiency) and emissions reductions; therefore the $20 million project budget with $8 million DOE share is very appropriate.

Reviewer 2:

The reviewer noted no need to change at this stage. Big project, but big challenges.

Reviewer 3:

The reviewer stated that on the surface, the allocated funds for this project ($8 million from the government) seems a bit excessive, because much seems to be in a state of flux. Presumably, there would be costs associated with having external suppliers providing services or goods. The reviewer added that it would seem that some element of budgetary scrutiny is appropriate given that some details of the project team were not provided in the presentation.

Ultra-Efficient Light-Duty Powertrain with Gasoline Low-Temperature Combustion: Keith Confer (Delphi Powertrain) - ace094

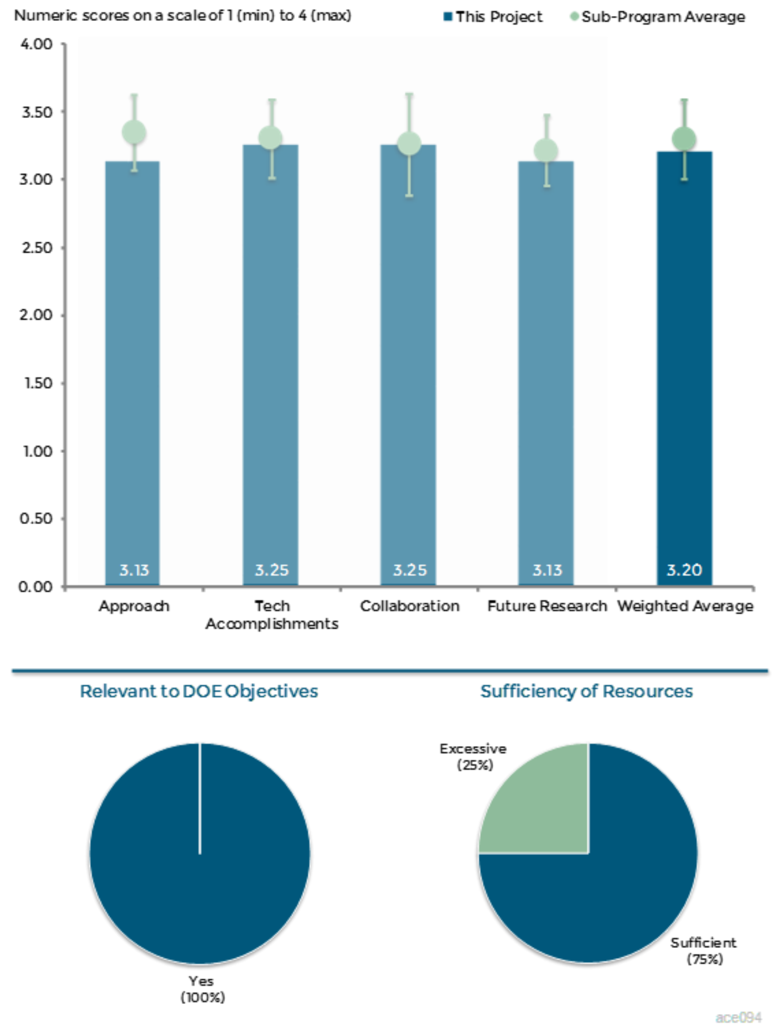

Figure 4-44 Ultra-Efficient Light-Duty Powertrain with Gasoline Low-Temperature Combustion: Keith Confer (Delphi Powertrain) – Advanced Combustion Engines

Presenter

Keith Confer, Delphi Powertrain.

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer said that while 35% FE improvement while meeting Tier 3 emissions is a challenging goal, a good approach was presented leveraging DOE ATP1 Delphi project award (2008-2013) to setup DOE ATP2 (this project) for success with strong partner expertise. Very good technical project plan with appropriate tasks, milestones and schedule was presented.

Reviewer 2:

The reviewer reported that the approach is traditional: SCE, generation 1 (Gen 1) MCE, generation 2 (Gen 2) MCE, simulation, emissions, and vehicle. Gasoline direct compression engine (GDCI) is a good combustion strategy to go after; Lund, Aramco, UW, Delphi, and Argonne National Laboratory are all working on it.

Reviewer 3:

The reviewer stated that this project is connected to efforts that began in 2008 which explored the viability of GDCI. That effort apparently resulted in an engine (to be used for the present project) with a vehicle that exceeded the targeted 35% efficiency limit for combined highway/city economy improvement with a warmed up engine. That vehicle/engine did not; however, appeared to not satisfy emissions performance targets, hence the present project. The reviewer added that the focus of this project is, therefore, to work to reduce harmful emissions while not sacrificing FE. The PI notes that the current effort will leverage the hardware developed from the prior effort with a new team with a focus on vehicle emissions. The engine platform will apparently be the same. The reviewer also said that the project is interesting but a rationale for the approach is lacking. A list of tasks is presented, for example, vehicle characterization, single cylinder engines, multi-cylinder engines, dynamometer testing, catalyst evaluation, debugging the single and multi-cylinder Gen2 engine developed in the first project, etc., but it was never clear precisely how the tasks would address emissions without also potentially influencing efficiency. The presentation indicated that “combustion efficiency as well as aftertreatment will be used to address emissions," which is fair enough, but not quantitative from the reviewer's perspective. The tasks were presented in the broadest terms.

Reviewer 4:

The reviewer did not see a strategy clearly articulated regarding how the Tier 3 emissions targets would be met and that was part of the milestones for 2014. The reviewer thought that this project could really benefit from closer coordination with Umicore on integrating the combustion and emissions control system strategies.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer observed that 28% FC reduction versus baseline is very impressive for Gen 1. More improvements coming with Gen 2 engine. The project is poised for progress, building project infrastructure. The reviewer added that impressive work on friction is a good example of how Gen 2 will improve over Gen 1. Relative to other similar GCI, it seems the project team is ahead.

Reviewer 2:

The reviewer said that this project was a new start (2014) but leveraging previous DOE ATP1 project work that showed potential for 39% FE improvement with similar gasoline direct injection compression ignition concept. This was accomplished at warmed up condition and did not meet Tier 2 Bin 2 goals of previous project. The reviewer added that a Gen2 engine setup (built outside of DOE funded project with HATCI) and simulations have been completed (first two milestones accomplished). Gen 1 development engines met full load MCE torque needs (20 bar peak) in dynamometer tests. The reviewer said that significant firing and motoring friction reduction results from Gen2 engine were also presented.

Reviewer 3:

The reviewer indicated that the project has made some gains. A vehicle is in place from the UFEV project and it is outfitted with a range of equipment. Some data show emission transients and new algorithms (not discussed) were developed to improve transient control; the algorithms are being calibrated. The reviewer added that a Gen2 engine was designed outside of DOE funded projects, and operated to evaluate injection strategies which is vague because the reviewer asked what the quantitative link is between 'injection strategies and efficiency or emission. The PI's team mounted their Gen2 engine on a dynamometer and is ready for testing, and all this may be good. The reviewer explained that the problem is that, as presented, it appeared like a disconnected collection of tasks. The PI needs to bring more focus to each of the tasks and better make the case for the necessity of the individual efforts.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer said that the project team has got some of the best. UW, Umicore, ORNL, and Hyundai. The reviewer added that it seemed that everyone is engaged. The project team needs to collaborate with the others working on this technology, ANL, Lund, others. The reviewer also stated that these partners likely have experiences and knowledge the project team can use. All these parties have vested interests in your project.

Reviewer 2:

The reviewer stated that the project team includes several industries, a national laboratory and a university. The role of each of these groups needs better focus. The reviewer added that for ORNL, their task is to analyze emissions samples; Hyundai is to develop and engineering design; UW is to perform characterization testing of gasoline fuel injectors; while Umicore will prepare low temperature exhaust samples. This is all good. The reviewer explained that what is missing is an interconnectedness and coordination that justifies the necessity for the deliverables which the collaborators will provide. For example, if the university partner is to characterize fuel injectors, the reviewer asked if the results will be used, what type of fuel injectors are used, and if these results are novel, or off-the-shelf, etc..

Reviewer 3:

The reviewer commented that the team is led by a large domestic Tier 1 supplier, supported by a vehicle OEM, emissions control manufacturer, DOE national laboratory with emissions core competency, and a leading combustion research university. ORNL emissions, HATCI, the OEM carryover from DOE ATP1 project, engine manufacturing, UW at Madison fuel injection characterization, and Umicore aftertreatment expertise makes a very good team. The reviewer added that there was appropriate and integrated team roles and responsibilities with proven previous collaboration experience.

Reviewer 4:

The reviewer noted that nothing was said about emissions control system hardware or integration of combustion strategy with strategies for HC and/or NO_x storage for cold start or about PM control. Tier 3 has very aggressive non-methane organic gas/ NO_x and US06 PM requirements.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that the project team had a good plan to refine the combustion, integrate emission control, and work on transients. Emissions issues will be key, but the reviewer is not too concerned, yet. Keep driving efficiency. The reviewer added that when emissions issues get critical, one may want to take a look at an engineering solution without compromising efficiency, pre-turbo oxidation catalyst. Turbo lag is addressed with supercharger and/or mild hybrid. The reviewer also said that this will also help keep the EGR cooler clean. Given this is a huge step-change in technology, one may as well go all the way

Reviewer 2:

The reviewer observed that the project team had an aggressive FE goals (35% improvement, diesel like efficiency) but building upon good results from a previous project, DOE ATP1. Developing a new low-temperature emissions aftertreatment system to achieve Tier 3 standards will be a significant challenge, the Tier 2, Bin 2 target of a previous project, was not met. Since the project is only six months into a four year schedule, as of AMR presentation submission, the proposed future work remains significant but seems appropriate.

Reviewer 3:

The reviewer reported that a challenge going forward is the development of an aftertreatment system commensurate with the highly efficient engine the group has developed, this is fine; however, it does not tell us much about the steps that are needed to improve the state of the art on aftertreatment concepts. The reviewer asked what fuel injectors are being tested. The reviewer then asked what is unique about them. The reviewer then asked what injector types are being tested. The reviewer also asked what their designs are. In addition the reviewer asked why these types are deemed attractive for meeting project goals. The importance of the plan going forward was evident in only the broadest terms who can argue that an aftertreatment system that is effective in dealing with a highly efficient engine would not be beneficial, but the reviewer asked what will be the strategy for developing this system, and therefore, much was vague.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer commented that the technology shows the best promise of DOE powertrain development to reduce fuel consumption. Diesel level efficiency with gasoline fuel.

Reviewer 2:

The reviewer said that this is a relevant project. The PI already has an engine that is efficient. The reviewer explained that what is needed is more effort to reduce its emissions, which apparently is the work of this project, though much of the approach was not clear.

Reviewer 3:

The reviewer stated that efficiency improvements in LD powertrain, or 35 % FE improvement target, result in lower fuel use and therefore a direct displacement of petroleum for passenger vehicles.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer remarked that this is a high importance and visibility project due to the aggressive goal of FE improvement (diesel like efficiency) and emissions reductions; therefore the nearly $10 million DOE budget share is very appropriate.

Reviewer 2:

The reviewer said large project, but good progress. Public funding seems suitable.

Reviewer 3:

The reviewer commented that at first impression, based on the information provided in the presentation, is that the provided resources are excessive. DOE is providing almost $10 million total to this project, where there was $3 million in 2015. The reviewer added that the PIs already have a gen2 GDCI engine developed outside of DOE funded projects. This new project that focuses on emissions controls now requires a government investment of $10 million. The reviewer also said that given that the PIs already have an engine it was not evident that a focus on emissions warranted such an expenditure, at least from what was presented. If the PIs feel otherwise, it would be appropriate to at least provide broad indications of what various project costs are. It was lack of clarity/information provided in the presentation that lead to this assessment as much was presented in only the broadest terms.

Metal Oxide Nano-Array Catalysts for Low-Temperature Diesel Oxidation: Pu-Xian Gao (University of Connecticut) - ace095

Presenter

Pu-Xian Gao, University of Connecticut.

Reviewer Sample Size

A total of five reviewers evaluated this project.

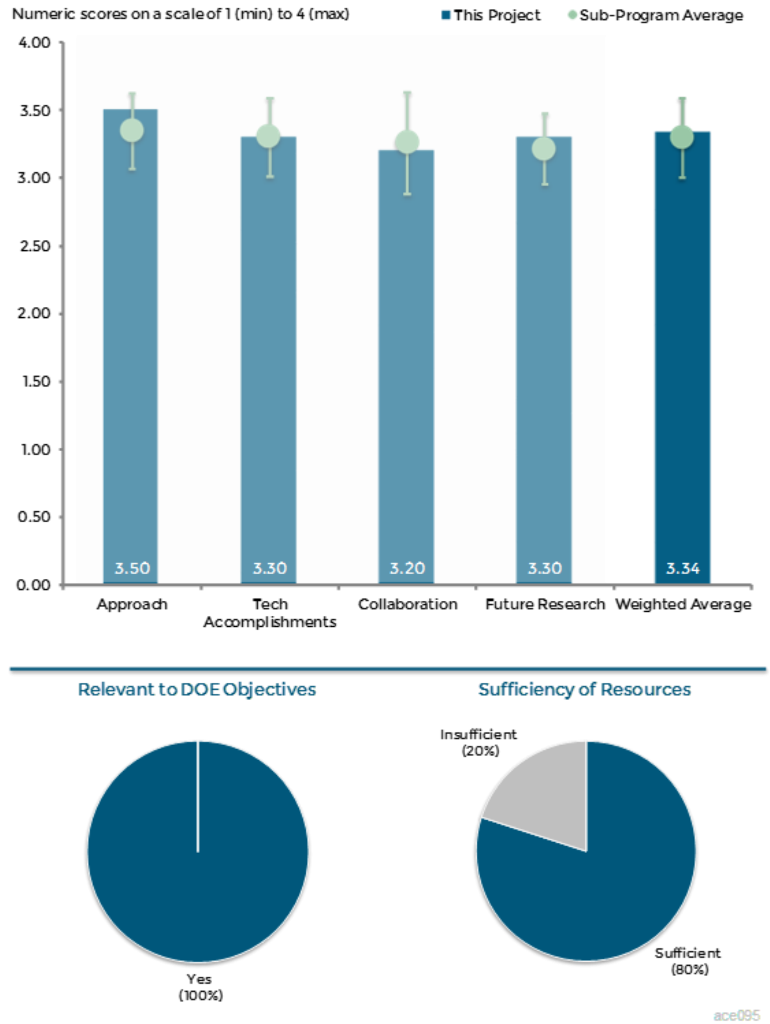

Figure 4-45 Metal Oxide Nano-Array Catalysts for Low-Temperature Diesel Oxidation: Pu-Xian Gao (University of Connecticut) – Advanced Combustion Engines

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer said that this is an exciting project because it uses a totally different approach to synthesizing the catalyst and applying it to the substrate. Wash coating produces an amorphous coating which is always being analyzed for the composition at the surface. The reviewer added that this approach is very clear as to the composition at the surface because it is being grown epitaxial.

Reviewer 2:

The reviewer remarked outstanding novel approach to grow and characterize nano-arrays on monolith with and without PGM using potentially scalable methods including solution and gas phase approaches. The reviewer added that a solid consideration of needs and requirements driven from the U.S. DRIVE The 150ºC Challenge Workshop Report, and 2013 U.S. DRIVE ACEC Technical Team Roadmap; lower temperature CO oxidation; HC oxidation; and NO_x reduction, reduced PGM, and better thermal aging stability.

Reviewer 3:

The reviewer reported that it is very important for this approach to show that there is sufficient surface area to carry out the reaction in real exhaust. So the testing criteria needs to be well spelled out as targets for known/reference catalysts and then these new catalysts. The reviewer added that a very wide range of materials has been chosen considering the time for the contract. Inclusion of ORNL team in project is also a key to the approach being kept focused on what may work in real catalyst systems.

Reviewer 4:

The reviewer commented that in general, this use of rare-earth and base metals as a substitute for precious metals is a novel approach to address very early inception stage research for the discovery of materials active for low-temperature CO oxidation; however, the conditions employed throughout the research project to date are far from those necessary to eliminate technologies early in the testing process. The reviewer added that the appropriate test conditions that include known CO and HC reaction inhibitors at low-temperature were not used in the screening process. Also, using aging conditions that will be experienced by these materials in their intended application were not widely used as a probe of activity and stability of the material. The reviewer added that using these variables as probes of activity will probably have saved considerable time to determine the viability of this technology.

Reviewer 5:

The reviewer said it would help to provide a definition of nano-array for those of us who are unfamiliar with this technology. Need to show effects of thermal aging on the activity for all of the catalysts, like the presenter did for the Pt/titanium oxide, or TiO_2, catalysts (for example, show light off performance before and after aging). The reviewer added that a catalyst needs to be able to tolerate at least 800°C with up to 10% H_2O in the exhaust.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer pointed out that there were excellent accomplishments demonstrating capability to grow and test PGM-free nano-array catalysts such as spinel $MxCo_3$ - xO_4, when M=Co, Ni and Zn. Zn-based data shows strong promise at 90% conversion of propane and 85% of CO at 350°C. The reviewer added that further promising results from samples with 0.3 weight Pt loaded TiO_2 and TiO_2-Al_2O_3 nano-array monoliths which resulted in 80% propane conversion at 250°C and some improved aging with TiO_2-Al_2O_3.

Reviewer 2:

The reviewer stated that coating on a monolith and doing the activity measurements are great accomplishments. The high water sensitivity and sulfur sensitivity is very disturbing even though the epitaxial growth methodology is great.

Reviewer 3:

The reviewer observed that the results with the NiCo catalysts were impressive and promising, particularly for C_3H_8 (propane) conversion. Again, the team needs to define the test conditions better, in regards to gas concentrations, space velocity, aging, etc.. The reviewer added that it would be good to include the results for a representative three-way catalyst to compare to the results for the NiCo and Co catalysts. It was unclear to this reviewer why the performance of the mesoporous Co_3O_4 catalyst fell off suddenly at 11 hours or so on Slide 14. The reviewer asked what regeneration means on the graph. The reviewer asked what does Meso-Mn-AR and Meso-Mn-HC mean on Slide 15. The reviewer said the perovskite catalysts looked to be a long way from a light-off temperature of 150°C. The reviewer asked if there is a reason to continue developing them. The Pt/TiO_2 conversions were good, especially with the alumina-stabilized titanium. The reviewer added that it is good to age the catalysts at 800°C as the project team did, as that is a minimum temperature for durability whether it is for diesel catalysts or for the underbody catalyst on a gasoline engine.

Reviewer 4:

The reviewer reported that very good progress was made in the characterization of multiple catalyst formulations using base test conditions. The HC species used were appropriate and represented challenging molecules to convert at low-temperature; however, using a growth technique to deposit an active catalyst material on a substrate may preclude the adoption of this technology. The reviewer added that manufacturability is a critical element to both OEMs and catalyst manufacturers. If the process to create the catalyst requires too production time and or cost, the likelihood of using this material is low. Therefore, the reviewer said that when developing an aftertreatment technology, both appropriate test conditions and manufacturability are key aspects to address before significant resources are employed for the project work.

Reviewer 5:

The reviewer commented that the growth of a number of samples has been accomplished along with catalytic characterization. The number of systems on the to-do list is large. It could be better to focus on the most promising and needed materials, even if others are easier to work with. The reviewer also stated testing of materials grown on the cordierite should include how the reactive surface area increases with added mass. There may be an optimum below the biggest mass. Also, the survival of the new growth in strong vibrations or sharp collisions should be tested.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer said there was excellent collaboration with national laboratories, a catalyst manufacturer, and novel nano-structure company.

Reviewer 2:

The reviewer reported that collaborations are sufficiently broad, with a full ORNL and Umicore involvement. These, particularly Umicore, should be useful, again to keep the evaluations realistic.

Reviewer 3: .

The reviewer stated that collaboration with ORNL and Umicore was mentioned along with Brookhaven National Laboratory.

Reviewer 4:

The reviewer commented that inclusion of an OEM or wash coat supplier to help determine the viability of the material and production process at an early stage would have benefited this project.

Reviewer 5:

The reviewer observed some evidence for collaboration with ORNL; however, it seems to be mostly professional advice, but that is clearly a step forward.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer remarked that there was an excellent map for future with metal oxide nano-array catalysts designed for: performance at 150°C or lower, optimized PGM loading with perovskite nano-particles, CO and HCs oxidation tests under simulated exhaust atmosphere, and engine testing in FY 2016. There is a possibility for future work inside or outside the effort with high potential once aging is confirmed is collaboration for nano-arrays deposition on exhaust sensors.

Reviewer 2:

The reviewer said that reasonable choice of future studies has been made. Down selection, as mentioned already, should be considered, because of the breadth of catalyst families in the program.

Reviewer 3:

The reviewer commented that the project team is proceeding down this pathway; however, there is no specific approach to mitigate the water and sulfur problems.

Reviewer 4:

The reviewer stated that the future work to address aging and environmental effects on the CO and HC activity of these materials is appropriate, but should have been employed at an earlier stage.

Reviewer 5:

The reviewer said that there is a need to include realistic aging conditions in all catalyst development. Fresh performance is not sufficient. The reviewer added that the project team needs to explore sulfur tolerance and desulfation capability of the more promising candidates. 2016 is probably premature for engine testing. The reviewer also stated that there is a lot of work to do to demonstrate low-temperature activity and durability on a lab reactor before proceeding to engine testing. The reviewed remarked that one has to walk before one can run.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer commented that low Pt and/or low temperature catalysis are major goals for the DOE. This project attacks both of these goals.

Reviewer 2:

The reviewer stated that this project supports U.S. Council for Automotive Research (USCAR)/U.S. DRIVE initiatives to address the need for low-temperature aftertreatment to produce viable solutions for emerging, higher efficiency combustion strategies.

Reviewer 3:

The reviewer reported that with the right results energy use should drop during cold start.

Reviewer 4:

The reviewer observed that the low-temperature catalysts will be needed for more efficient engines in the future that produce lower exhaust temperatures.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented that with initial proof of concept success at full scale catalyst size and vetting of potential for production volume application, additional partners and funding could significantly improve the time to production impact of this outstanding approach and preliminary result.

Reviewer 2:

The reviewer stated that this project is appropriately funding, but a wash coat supplier should have been consulted or used to help direct the research activities.

Reviewer 3:

The reviewer said that the resources appear to be sufficient.

Acronyms and Abbreviations

1D	One dimensional
3D	Three dimensional
ACE	Advanced combustion engine
ACEC	Advanced Combustion and Emissions Control
AEC	Advanced Engine Combustion
AFCI	Advanced Fuel Cycle Initiative
AFR	Air to fuel ratio
AKI	Anti-Knock Index
AMR	Annual Merit Review
ANL	Argonne National Laboratory
APS	Advanced photon source
ARRA	American Recovery and Reinvestment Act
Au	Gold
AVFL	Advanced Vehicle/Fuel/Lubricants
BES	DOE Basic Energy Sciences
BMEP	Brake Mean Effective Pressure
BP	Bandpass
BSFC	Brake-specific fuel consumption
BSG	Belt-Driven Starter-Generator
BTE	Brake Thermal Efficiency
C	Centigrade
Ca	Calcium
CAFE	Corporate Average Fuel Economy
CARB	California Air Resources Board
CCC	Co-precipitated CuOX, CoOy, and Ceo2 catalyst
CCV	Cycle-to-cycle variability
CDC	Conventional diesel combustion

CFD	Computational Fluid Dynamics
CH4	Methane
CHA	Chabazite
CI	Compression Ignition
CLEERS	Cross-Cut Lean Exhaust Emissions Reduction Simulations
CNT	Carbon Nanotubes
CO	Carbon Monoxide
CO2	Carbon Dioxide
COV	Coefficient of variance
CPU	Central processing unit
CR	Compression Ratio
CRF	Combustion Research Facility
CRADA	Cooperative Research and Development Agreement
CRC	Coordinating Research Council
CSC	Cold Start Concept
CT	Computed tomography
Cu	Copper
CZ	Ceria-zirconia
dBA	Decibel
D-EGR	Dedicated-Exhaust Gas Recirculation
DC	Direct current
DI	Direct Injection
DISI	Direct Injection Spark Ignited
DOC	Diesel oxidation catalyst
DOD	U.S. Department of Defense
DOE	Department of Energy
DNS	Direct numerical simulation
DPF	Diesel particulate filter

DRG	Diagnosis-related group
DSNY	City of New York Department of Sanitation
DTBP	Di-t-butyl peroxide
E0	0% ethanol blend with gasoline
E10	10% ethanol blend with gasoline
E20	20% ethanol blend with gasoline
E85	85% ethanol blend with gasoline
EATS	Exhaust after-treatment system
ECN	Engine Collaboration Network
ECS	Emission control system
ECU	Engine control unit
EGR	Exhaust Gas Recirculation
EHN	2-ethylhexyl nitrate
EHR	Exhaust heat recovery
EPA	U.S. Environmental Protection Agency
ERC	Engine Research Center
FA	Field Aging
FACE	Fuels for Advanced Combustion Engines
FE	Fuel Economy
FEA	Finite element analysis
FGM	Flamelet generated manifold
FMEP	Friction mean effective pressure
FST	Filter sensing technologies
FTP	Federal Test Procedure
FTIR	Fourier Transform Infrared Spectroscopy
FY	Fiscal year
g	gram
GCI	Gasoline compression ignition

GDI	Gasoline Direct-injected
GDCI	Gasoline Direct Compression Engine
GE	General Electric
GFR	Glomerular filtration rate
GHG	Greenhouse gas
GM	General Motors Corporation
GPF	Gasoline Particulate Filter
GPU	Graphics Processing Unit
GSA	Global sensitivity analysis
GTDI	Gasoline Turbocharged Direct Injection
H2	Hydrogen
H2O	Water
HC	Hydrocarbon
HCCI	Homogeneous Charge Compression Ignition
HCl	Hydrogen chloride
HD	Heavy-Duty
HECC	High efficiency clean combustion
HEDGE	High-Efficiency Dilute Gasoline Engine
HPC	High Performance Computing
HV	High voltage
ICE	Internal Combustion Engine
ICT	Institute of Chemical Technology
IDT	Ignition delay times
IMEP	Indicated Mean Effective Pressure
IP	Intellectual property
IR	Infrared
ISFC	Indicated Specific Fuel Consumption
ITE	Indicated Thermal Efficiency

K	Potassium
Kn	Knudsen Number
L	Liter
La	lanthanum
LANL	Los Alamos National Laboratory
LBNL	Lawrence Berkeley National Laboratory
LD	Light-Duty
LDA	Laser doppler anemometry
LES	Large Eddy Simulation
LEV	Low Emission Vehicle
LIF	Laser-induced fluorescence
LLNL	Lawrence Livermore National Laboratory
LNT	Lean NOx Trap
LPL	Low-pressure loop
LT	Low temperature
LTC	Low Temperature Combustion
LTGC	Low Temperature Gasoline Combustion
MBC	Model based controls
MCE	Multi-cylinder engine
MD	Medium-Duty
Mg	Magnesium
MIT	Massachusetts Institute of Technology
mJ	Millijoule
Mn	Manganese
MOU	Memorandum of Understanding
MPG	Miles Per Gallon
ms	Milliseconds
MSU	Michigan State University

MTU	Michigan Technological University
N2	Nitrogen
N2O	Nitrous Oxide
NA	Naturally aspirated
NG	Natural gas
NH3	Ammonia
NIST	National Institute of Standards and Technology
NMOG	Non-methane organic gases
NO	Nitric Oxide
NOx	Oxides of Nitrogen
NO2	Nitrogen Dioxide
NREL	National Renewable Energy Laboratory
NSC	NOx Storage Catalyst
NSF	National Science Foundation
NSR	NOx Storage Reduction
NVH	Noise, vibration, and harshness
NVO	Negative Valve Overlap
O2	Oxygen
OBD	On-Board Diagnostics
OEM	Original Equipment Manufacturer
OH	Hydroxide
ORC	Organic Rankine Cycle
ORNL	Oak Ridge National Laboratory
OSC	Oxygen storage capacity
OSU	Ohio State University
PAH	Polycyclic aromatic hydrocarbon
PCCI	Premixed Charge Compression Ignition
PDT	Pulse discharge technique

PFI	Port Fuel Injection
PFS	Partial fuel stratification
PGM	Platinum group metal
PI	Principal Investigator
PIV	Particle image velocimetry
PM	Particulate matter
PN	Particulate number
PNA	Passive NOx adsorber
PNNL	Pacific Northwest National Laboratory
POD	Proper orthogonal decomposition
PPC	Partially Premixed Combustion
ppm	Part per million
Pr	Praseodymium
Pt	Platinum
PWM	Pulse width modulation
R&D	Research and development
RANS	Reynolds-Averaged Navier Strokes
RCCI	Reactivity Controlled Compression Ignition
RCM	Rapid compression machines
RF	Radio frequency
Rh	Rhodium
ROI	Return on investment
RON	Research octane number
SACI	Spark assisted compression ignition
SAE	Society of Automotive Engineers
SCR	Selective Catalytic Reduction
SCRF	Selective catalytic reduction on filters
SEM	Scanning electron microscope

SI	Spark-ignition
SIDI	Spark-ignition direct-injection
SMD	Sauter Mean Diameter
SNL	Sandia National Laboratories
SOF	Solvent extractable fraction
SULEV	Super Low-Emission Vehicle
SUV	Sport utility vehicle
TARDEC	U.S. Army Tank and Automotive Research, Development and Engineering Center
TCR	Thermochemical recuperation
TDC	Top dead center
TE	Thermoelectric
TEG	Thermoelectric Generator
TJI	Turbulent jet ignition
TRD	Transmission radiation detector
TWC	Three-Way Catalyst
UC	University of California
UConn	University of Connecticut
UHC	Unburned hydrocarbons
UM	University of Michigan
UQ	Uncertainty quantification
USCAR	U.S. Council for Automotive Research
U.S. DRIVE	U.S. Driving Research and Innovation for Vehicle Efficiency and Energy sustainability
UW	UW
UWM	UW-Milwaukee
VCR	Variable compression ratio
VCT	Variable camshaft timing
VTO	Vehicle Technologies Office
VUV	Vacuum ultraviolet

VVA	Variable Valve Actuation
WHR	Waste Heat Recovery
WSU	Washington State University
XAFS	X-ray absorption fine structure
XPS	X-ray photoelectron spectroscopy
Zr	Zirconium
ZT	Thermoelectric Figure of Merit

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5. Fuels and Lubricants Technologies

As transportation accounts for two-thirds of the nearly $1 billion the U.S. spends daily on foreign oil, it is vital to increase our use of alternative fuels. Increasing the fuels available to drivers reduces price volatility, supports domestic industries, and increases environmental sustainability. The U.S. Department of Energy (DOE) Vehicle Technologies Office (VTO) supports research to improve how vehicles use these many of these fuels in the future, as well as activities to increase their availability today.

Reaching VTO's goals will help the country meet the Renewable Fuel Standard's goals for use of biofuels in the Energy Policy Act of 2005 and the Energy Independence and Security Act of 2007. These goals require the use of as much as 36 billion gallons of renewable fuels annually by 2022.

To reach these goals, VTO supports activities to:

- Research fuels' effects on combustion: Improves understanding of how fuels from new sources can affect advanced combustion systems.
- Research lubricants: Works to develop lubricants that can improve the fuel economy of vehicles in the current fleet.
- Research natural gas: Works to support the development of natural gas engines and renewable natural gas projects.
- Research biofuels and their effects on combustion: Works to determine the impact of biofuels' properties on engines' efficiency, performance, and emissions. Activities include examining ways to increase alternative fuel vehicles' fuel economy, investigating the potential effects of upcoming blends, and improving the quality of current and future biofuel blends, especially biodiesel and E85.

The Fuel and Lubricant Technologies subprogram supports research and development (R&D) to provide vehicle users with cost- competitive options that enable high fuel economy (FE) with low emissions, and contribute to petroleum displacement. This is accomplished through exploitation of fuel properties to enable advanced combustion, development of efficiency-improving lubricants compatible with new and existing engines and vehicles, and fit-for-service evaluations of low-carbon alternatives to petroleum-based fuels. Future transportation fuels will be produced from refinery feedstocks derived increasingly from non-conventional sources including heavy crude, oil sands, shale oil, coal, and renewable resources such as biomass, vegetable oils, and waste animal fats. The impact of changes in refinery feedstocks and processes on finished fuels is an area of interest in terms of impacts on engines, emissions regulations, and end uses. Additionally, new lubricants will require increasingly sophisticated additive packages and higher-quality base fluids that can deliver higher efficiency with better engine protection.

Subprogram activities are intended to: (1) enable future advanced combustion regime engines and emission control systems to be more efficient while meeting future emission standards; (2) develop efficiency-improving lubricants including products compatible with legacy vehicles (i.e., enabling lubricant retrofits); and, (3) reduce reliance on petroleum-based fuels through direct fuel substitution by non-petroleum-based fuels. These activities are coordinated with and supportive of the U.S. Environmental Protection Agency's fuels- and emissions-related activities, as mentioned in their strategic plan.

The major subprogram goals for Fuel and Lubricant Technologies are:

- By 2015, expand operational range of low-temperature combustion to 75% of light-duty Federal Test Procedure (FTP).

- By 2015, demonstrate-cost effective lubricant with 2% FE improvement.

The Energy Independence and Security Act of 2007 (EISA, P.L. 110-140) mandates the use of enormous amounts of renewable fuels (36 billion gallons annually by 2022). Current ethanol markets are not able to absorb the volumes mandated; use of intermediate blends may be required. In addition, future feedstocks for fuel production are expected to come from alternative fossil sources. Understanding the impact of these fuels and fuel blends on current and advanced combustion engines is critical to increasing their use. Technical issues that need to be addressed include: lack of data and tools for predicting fuel and lubricant property effects on engine operation; fuel and lubricant effects on emissions and emission control systems. This subprogram is developing data and tools, in collaboration with many partners in industry, academia and government impacting new and old vehicles, as well as small non-road engines.

Subprogram Feedback

DOE received feedback on the overall technical subprogram areas presented during the 2015 Annual Merit Review (AMR). Each subprogram technical session was introduced with a presentation that provided an overview of subprogram goals and recent progress, followed by a series of detailed topic area project presentations.

The reviewers for a given subprogram area responded to a series of specific questions regarding the breadth, depth, and appropriateness of that DOE VTO subprogram's activities. The subprogram overview questions are listed below, and it should be noted that no scoring metrics were applied. These questions were used for all VTO subprogram overviews.

Question 1. Was the program area, including overall strategy, adequately covered?

Question 2. Is there an appropriate balance between near- mid- and long-term research and development?

Question 3. Were important issues and challenges identified?

Question 4. Are plans identified for addressing issues and challenges?

Question 5. Was progress clearly benchmarked against the previous year?

Question 6. Are the projects in this technology area addressing the broad problems and barriers that the Vehicle Technologies Office (VTO) is trying to solve?

Question 7. Does the program area appear to be focused, well-managed, and effective in addressing VTO's needs?

Question 8. What are the key strengths and weaknesses of the projects in this program area? Do any of the projects stand out on either end of the spectrum?

Question 9. Do these projects represent novel and/or innovative ways to approach these barriers as appropriate?

Question 10. Has the program area engaged appropriate partners?

Question 11. Is the program area collaborating with them effectively?

Question 12. Are there any gaps in the portfolio for this technology area?

Question 13. Are there topics that are not being adequately addressed?

Question 14. Are there other areas that this program area should consider funding to meet overall programmatic goals?

Question 15. Can you recommend new ways to approach the barriers addressed by this program area?

Question 16. Are there any other suggestions to improve the effectiveness of this program area?

Responses to the subprogram overview questions are summarized in the following pages. Individual reviewer comments for each question are identified under the heading Reviewer 1, Reviewer 2, etc. Note that reviewer comments may be ordered differently; for example, for each specific subprogram overview presentation, the reviewer identified as Reviewer 1 in the first question may not be Reviewer 1 in the second question, etc.

Subprogram Overview Comments: Kevin Stork (U.S. Department of Energy) – ft000

Question 1: Was the program area, including overall strategy, adequately covered?

Reviewer 1:

The reviewer said yes, overall strategies in the areas of fuels, engines, and lubricants were clearly explained with focus on reducing dependence on petroleum, meeting increased fuel economy standards, and further reducing exhaust emissions to meet future regulations.

Reviewer 2:

The reviewer said that the overall strategy in the fuels and lubricant area of predictive modeling development, development of science mechanistic based models, lubricant technology development, engineered surface technology development, and validation of modeling and technologies was adequately discussed.

Reviewer 3:

The reviewer said yes, the overall strategy was developed and explained very well. The history of compression ratio and fuel octane was covered well.

Question 2: Is there an appropriate balance between near- mid- and long-term research and development?

Reviewer 1:

The reviewer said that the strategy spans the spectrum from near-term to longer-term R&D. The nearer-term includes lubricant improvements that could be taken advantage of by current vehicles (i.e., small improvements x large number of vehicles = large benefits). The longer term includes R&D on advanced low-carbon fuels and engines to significantly improve fuel economy (and thus lower petroleum dependence) and further reduce engine-out emissions.

Reviewer 2:

The reviewer said that future direction included fiscal year (FY) 2020 long term goals to demonstrate a lubricant system with 4% fuel economy improvement relative to 2013 fluids. The reviewer noted that near- and mid-term future activities were also identified through the development of retrofittable low-friction lubes for drop-in replacement in existing vehicle engines. Continue fit for service evaluations of alternative fuels with emphasis on drop-in biofuels.

Reviewer 3:

The reviewer said that existing projects and their time horizon was not covered well, and so the reviewer could not get a good idea about the balance.

Question 3: Were important issues and challenges identified?

Reviewer 1:

The reviewer said yes, and detailed that especially the challenges associated with developing advanced combustion engines that could be operated full-time using lower carbon, mass market fuels.

Reviewer 2:

The reviewer said yes. Issues and challenges were identified through the discussion of the need to raise octane in future fuels to enable a maximum compression ratio. Three automotive challenges were identified of emissions reduction, fuel economy increases and meeting the renewable fuels standard.

Reviewer 3:

The reviewer said that issues were identified in a big picture way. However, the reviewer noted that what issues and challenges projects currently underway were addressing was not adequately covered.

Question 4: Are plans identified for addressing issues and challenges?

Reviewer 1:
The reviewer said yes, clear programs and plans are in place to attempt to overcome the challenges.

Reviewer 2:
The reviewer said yes, in a big picture (i.e., OPTIMA) way.

Reviewer 3:
The reviewer said that there was a good discussion about the near-term approach to increase fuel economy through the use of fuels that includes reduced engine displacement, reduced engine speed, and the requirement to improve engine power density. The reviewer noted that because power density is limited by octane rating it will be important to work on increasing octane rating.

Question 5: Was progress clearly benchmarked against the previous year?

Reviewer 1:
The reviewer detailed that several recent accomplishments were mentioned, including 2% fuel economy improvement from development of advanced additives in lubricant oils, and expansion of the potential engine operating range in reactivity controlled compression ignition (RCCI) advanced combustion.

Reviewer 2:
The reviewer said yes, and detailed that accomplishments demonstrated 2% fuel economy improvement with advanced additives. In addition, the RCCI operating range of 75% of city and highway light-duty federal drive cycles was demonstrated.

Reviewer 3:
The reviewer asserted that most time was devoted to setting up and developing the big picture, which was done well. However, very little time was devoted to clearly benchmark progress against the previous year. When the reviewer went to last year's overview presentation to prepare, the reviewer was surprised to find that there was very little difference between the 2014 and 2015 presentations. The reviewer understands the big picture does not change in one year, and the reviewer is not contesting that part. The reviewer is noting that hardly any time was spent in both 2014 and 2015 to cover progress of current projects against issues and challenges.

Question 6: Are the projects in this technology area addressing the broad problems and barriers that the Vehicle Technologies Office (VTO) is trying to solve?

Reviewer 1:
The reviewer said yes, projects are focused on reducing dependence on petroleum, meeting increased fuel economy standards, and further reducing exhaust emissions to meet future regulations, which are key goals of the Vehicle Technologies Office (VTO).

Reviewer 2:
The reviewer said that the projects in this technology area adequately address both fuels and lubricants and how they affect emissions and fuel economy.

Reviewer 3:
The reviewer could not conclude from this overview presentation. The reviewer would have to go to each individual principal investigator’s (PI) presentation to know that.

Question 7: Does the program area appear to be focused, well-managed, and effective in addressing VTO's needs?

Reviewer 1:

The reviewer said yes, for the limited budget the program is well focused and effective. With additional funds more progress would be possible, which would help address DOE's goals faster.

Reviewer 2:

The reviewer said that yes, the program does appear to be focused, well managed, and effectively address VTO's needs.

Reviewer 3:

The reviewer questioned whether the program seems to be in transition. The reviewer elaborated that the program seems to be in a mode of anticipation, like something big is going to change. The reviewer gathers it is the idea of co-optimizing engines and fuels. The reviewer pointed out that most time was spent selling that idea (i.e., OPTIMA).

Question 8: What are the key strengths and weaknesses of the projects in this program area? Do any of the projects stand out on either end of the spectrum?

Reviewer 1:

The reviewer said that projects led by the national laboratories looking at fuel effects on advanced combustion engines continues to be a very positive part of the program.

Reviewer 2:

The reviewer said that key strengths are focusing on both the engine and the fluid components (fuels and lubricants), and focusing on a spectrum of projects from near-term to long term. The reviewer said that a possible weakness is that ultimate success depends on development of cost-effective technologies that can be implemented in the marketplace and accepted by the majority of consumers. Also, recent experience suggests that some alternative fuel candidates have other potential, higher value uses (i.e., cosmetics and specialty chemicals) and will likely not ultimately be used in fuels.

Reviewer 3:

The reviewer said that the projects in this area were not listed, overviewed, or described in any way in this presentation, and so the reviewer could not get an idea of their strengths and weaknesses.

Question 9: Do these projects represent novel and/or innovative ways to approach these barriers as appropriate?

Reviewer 1:

The reviewer said yes, especially the focus on developing advanced combustion engines and the fuels that would enable them.

Reviewer 2:

The reviewer said yes, the work performed at the national laboratories continues to be very innovative and a major part of the program.

Reviewer 3:

The reviewer cited comments made for question eight.

Question 10: Has the program area engaged appropriate partners?

Reviewer 1:

The reviewer said that there seems to be good engagement with industry and cited as an example the U.S. DRIVE initiatives.

Reviewer 2:
The reviewer said yes, the program has a good selection of partners including the national laboratories and some automotive and additive companies. The reviewer said that some of the laboratories are involved with the Coordinating Research Council (CRC), which helps bring good industry input into the projects.

Reviewer 3:
The reviewer said that none of the slides gave any idea of the partners involved, and the oral presentation did not give any idea either.

Question 11: Is the program area collaborating with them effectively?

Reviewer 1:
The reviewer said yes, appears to be effective collaboration with industry, particularly the original equipment manufacturers (OEMs), although less so with the energy companies.

Reviewer 2:
The reviewer said that there seems to be good collaboration with all of the partners.

Reviewer 3:
The reviewer referenced comments made in question 10.

Question 12: Are there any gaps in the portfolio for this technology area?

Reviewer 1:
The reviewer did not identify any gaps.

Reviewer 2:
The reviewer said no, there do not appear to be any gaps in the portfolio.

Reviewer 3:
The reviewer was not able to get an idea of the portfolio of projects from the presentation.

Question 13: Are there topics that are not being adequately addressed?

Reviewer 1:
The reviewer said no topics are not being adequately addressed.

Reviewer 2:
The reviewer said that it would be good to begin more work in the area of co-development of engines and fuels to help increase fuel economy.

Reviewer 3:
The reviewer could not get an idea of topics from the presentation for fuels. The reviewer said Slide 16 gave a broad topic area for lubricants, but could not get an idea if these areas are being covered well.

Question 14: Are there other areas that this program area should consider funding to meet overall programmatic goals?

Reviewer 1:
The reviewer said there are no other areas that this program should consider funding.

Reviewer 2:
The reviewer said that the big idea discussed of co-optimizing fuels and engines to reduce per-vehicle consumption 30% versus 2030 base case should be considered for funding. The reviewer noted that it was not clear in the presentation if it was funded or not.

Reviewer 3:
The reviewer said fuels for spark-ignited, gasoline, down-sized, boosted, dilute combustion, high-efficiency engine pathways should be included in the portfolio if they are not already included. The reviewer indicated that there are research areas like the effect of fuel sensitivity (research octane number and motor octane number (RON-MON)), heat of vaporization (HOV), and particulate matter index (PMI) in which industry will be very interested.

Question 15: Can you recommend new ways to approach the barriers addressed by this program area?

Reviewer 1:
The reviewer had no recommendations.

Reviewer 2:
The reviewer said that the new reality discussed that fuel octane rating now influences fuel economy should definitely be factored into the program.

Reviewer 3:
The reviewer noted that the U.S. DRIVE Advanced Combustion and Emissions Control (ACEC) Tech Team has recently completed their roadmap for future fuels. The reviewer noted that there is enough research content even in the near term gasoline fuels, like those mentioned in the response to question 14.

Question 16: Are there any other suggestions to improve the effectiveness of this program area?

Reviewer 1:
The reviewer had no suggestions, and clarified that for the funding available, the program seems to be very effective.

Reviewer 2:
The reviewer had no suggestions.

Reviewer 3:
The reviewer said that the effect of biofuels on blended fuel properties and the response of downsized, boosted gasoline engines, and dilute gasoline combustion should be added to the portfolio if it is not already in there.

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.

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Advanced Combustion and Fuels	Zigler, Brad (NREL)	5-11	3.25	3.17	3.25	3.17	3.20
Performance of Biofuels and Biofuel Blends	McCormick, Bob (NREL)	5-16	3.67	3.50	3.67	3.33	3.54
Fuel Effects on Mixing-Controlled Combustion Strategies for High-Efficiency Clean-Combustion Engines	Mueller, Chuck (SNL)	5-19	3.50	3.70	3.60	3.20	3.58
Advanced Lean-Burn DI Spark Ignition Fuels Research	Sjoberg, Magnus (SNL)	5-23	3.40	3.60	3.40	3.40	3.50
Fuel Effects on Emissions Control Technologies	Toops, Todd (ORNL)	5-27	3.38	3.25	3.50	3.13	3.30
Gasoline-Like Fuel Effects on Advanced Combustion Regimes	Szybist, James (ORNL)	5-31	3.50	3.25	3.50	3.25	3.34
Engine Friction Reduction Technologies	Fenske, George (ANL)	5-35	3.38	3.50	3.75	3.50	3.50

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Polyalkylene Glycol (PAG) Based Lubricant for Light- and Medium-Duty Axles	Gangopadhyay, Arup (Ford)	5-38	3.67	3.50	3.50	3.33	3.52
A Novel Lubricant Formulation Scheme for 2% Fuel Efficiency Improvement	Wang, Q. Jane (Northwestern University)	5-41	3.63	3.25	3.63	3.25	3.39
Improve Fuel Economy through Formulation Design and Modeling	Wu, Gefei (Ashland)	5-44	3.38	2.88	3.25	3.25	3.09
Developing Kinetic Mechanisms for New Fuels and Biofuels	Pitz, Bill (LLNL)	5-47	3.38	3.63	3.50	3.38	3.52
Unconventional and Alternate Fuels Research	Bays, Tim (PNNL)	5-50	3.17	3.17	3.00	3.00	3.13
Additive and Basefluid Development	Ajayi, Oyelayo (ANL)	5-53	3.38	3.38	3.63	3.38	3.41
Overall Average			**3.44**	**3.37**	**3.48**	**3.27**	**3.39**

Advanced Combustion and Fuels: Brad Zigler (National Renewable Energy Laboratory) - ft002

Presenter

Brad Zigler, National Renewable Energy Laboratory.

Reviewer Sample Size

A total of six reviewers evaluated this project.

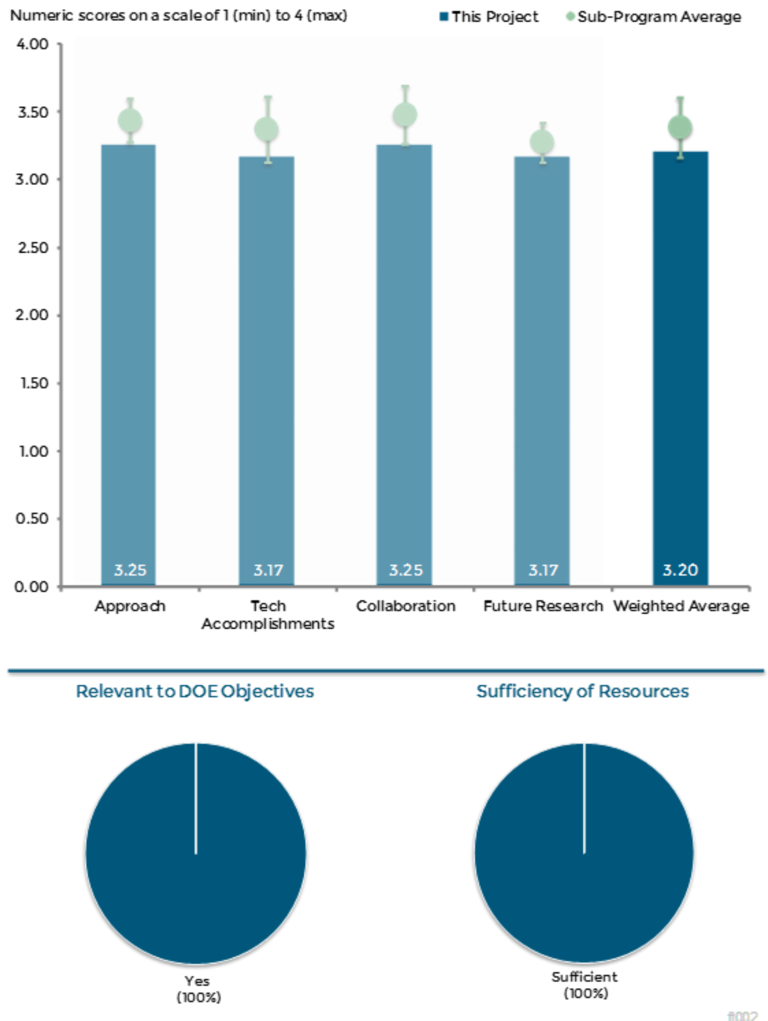


Figure 5-1 Advanced Combustion and Fuels: Brad Zigler (National Renewable Energy Laboratory) – Fuel and Lubricant Technologies

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer observed an excellent project approach and strategy of developing techniques, tools, and data to quantify critical fuel effects to help development of advanced combustion engines that use alternative fuels.

Reviewer 2:

The reviewed remarked that the approach of extending the capabilities of the ignition quality tester (IQT) instrument to obtain more fundamental information about the properties and combustion characteristics of fuels is very good.

Reviewer 3:

The reviewer noted that the project continues work on and with the IQT and introduces a new single cylinder engine for fuel efficiency studies. These are both useful areas of research.

The National Renewable Energy Laboratory (NREL) has spent many years developing and modifying the IQT and has made great progress in broadening its application and providing more accurate, consistent data.

Reviewer 4:

The reviewer found that the combination of facilities and collaborations makes this a strong approach to improving understanding of the ignition and combustion behavior of fuels. The IQT being used as a primary tool is limited in some respects, due to its pressure limits and limited range of operability. According to the reviewer, this weakness is being addressed through collaboration with other facilities that can consider a broader range of temperature and pressure conditions. Given the vagaries of cetane number (CN) and derived cetane number (DCN) ratings, relying on a combination of cetane rating and ignition delay measurements, and reporting and comparing on the basis of ignition delay, is a good approach too. The reviewer applauded that the project has responded very well to reviewer feedback to date.

Reviewer 5:

The reviewer observed that the approach considers modelling/ tools development, empirical data, collaboration and info sharing.

Reviewer 6:

The reviewer observed that the IQT device has some weaknesses in the quality of the ignition delay data. Nevertheless, it is an accepted approach by the community. The reviewer commented that the use of a modern turbocharged engine to supplement the fuels work is encouraged and should be continued.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer observed that despite the funding cutback in 2015, the project appears to be continuing to make very good progress and contribute to the fuels and combustion community. The growing understanding of the ignition behavior of ethanol-based fuels, and fuels for advanced strategies such as gasoline compression ignition (GCI) are strong contributions. The expansion of collaboration with Argonne National Laboratory (ANL) is a good development, because there is natural overlap between these ignition studies and the GCI engine studies at ANL.

The reviewer applauded that an update of the CN Compendium is a significant outcome and valuable service/deliverable from this project. The results explaining ignition behavior of model fuel mixtures (isooctane blends, ethanol blends) is valuable fundamental ignition research.

Reviewer 2:

The reviewer commented that technical accomplishments in the areas of engine studies for high octane fuels, kinetic studies of octane references, and kinetic studies of ethanol blends has been very good.

Reviewer 3:

The reviewer remarked the IQT data on the different ethanol blends is very interesting and will be useful going forward.

Reviewer 4:

The reviewer commented that DCN is a key industry standard testing coming from NREL for little known fuels/compounds. Regarding octane, the reviewer commented that kinetic studies of ignition delay via IQT to better quantify research or motor octane numbers (RON/MON) are very important because data gaps exist to the true effects of oxygenates with physics of fuel spray, thermodynamics of fuel evaporation, along with delay associated with octane rating. The reviewer observed excellent insights into reduced ignition delay at higher temps versus primary reference fuel for ethanol fuel blends, HOV effect versus octane as well as negative temperature coefficient behavior at E20+.

Regarding single cylinder gasoline direct injection (GDI), the reviewer commented that upstream injection in combination with direct injection to eliminate HOV impact could truly assess fuel chemical effects. The reviewer applauded excellent isolation of octane from injection strategy/HOV effects.

Reviewer 5:

The reviewer commented that NREL has provided a valuable update and expansion of the CN Compendium.

Extending the IQT to gasoline range fuels allows the ability to study a continuum between gasoline and diesel fuels.

The reviewer noted that the graphs presented indicate that the IQT provides interesting and consistent measurements, but more comparisons with and application to kinetic modeling results need to be seen. The reviewer thought that it is an interesting observation that IQT needs a complex computational fluid dynamics (CFD) model for short ignition delays but transitions to a 0-D premixed model for long ignition delays.

Reviewer 6:

The reviewer observed good progress on measuring the ignition delays of various fuel formulations, including blends with ethanol. Interesting trends obtained that depend on fuel formulation and not necessarily solely by octane number. The reviewer commented that value of this data will be greatly enhanced when a better understanding of the reasons for the fuel behaviors and their relevance to engine combustion is elucidated.

The use of the single cylinder engine to separate out the effects of octane and heat of vaporization looks interesting and promising.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer observed that this project has strong connections to multiple other institutions, including the CRC. This project has very good visibility due to the extensive collaboration and coordination with industry, government and academic partners. The reviewer remarked that the partnerships also enable this project to have a long lasting a wide impact that can benefit many other DOE projects by filling data voids and promoting improvement of kinetic mechanisms and thereby predictive tools.

Reviewer 2:

The reviewer observed collaboration mostly with the other national laboratories and universities. Some collaboration with industry through participation and contribution to the CRC Fuels for Advanced Combustion Engines (FACE) Working Group.

Reviewer 3:

The reviewer complimented that collaboration in this project continue to be excellent. Coordination with Lawrence Livermore National Laboratory (LLNL), ANL and universities such as Colorado School of Mines, University of California-Berkeley and University of Michigan all help to make this project a success. The reviewer noted that interactions with the CRC bring input from industry, which is valuable to the project.

Reviewer 4:

The reviewer noted key collaboration with academia and pointed out as collaborators the Colorado School of Mines and the University of Michigan.

Reviewer 5:

The reviewer commented that sharing and complementing work with universities broadens usefulness of results, including the excellent collaboration with Colorado School of Mines.

The reviewer pointed out that there seems to be a lack of collaboration with industry except through the Advanced Engine Combustion (AEC) Memorandum of Understanding (MOU). Sharing results with LLNL is very good, but there needs to be more information about how the results are being used and what has improved as a result.

Reviewer 6:

The reviewer suggested that more direct input should be received from engine original equipment manufacturers (OEMs) to make sure that the big picture is correct. For example, the reviewer asked why is the GCI low-temperature combustion (LTC) concept quoted as the choice for LTC fuels work, and inquired if that is the voice of the auto industry.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer commented that plans seem to build on progress to date and moving towards accomplishing objectives.

Reviewer 2:

The reviewer said that the presentation identified the remaining challenges and barriers, and the future research proposed to continue to work on these barriers seems reasonable.

Reviewer 3:

The reviewer recommended that key research needs to continue, especially in the isolation/better determination of octane effects versus other effects such as HOV and sensitivity. The reviewer suggested that the project needs to address impact of GDI strategy (wall guided versus spray guided) on results (e.g., spray guided effectiveness on low-speed pre-ignition).

Reviewer 4:

The reviewer commented that the plans to separate the effects RON, sensitivity, and HOV effects will be extremely useful going forward. The reviewer suggested that biofuel blends should be included in this matrix of fuels. Also, while it is not the focus, routine measurements of engine emissions, particularly particulate emissions, engine efficiency, etc., should be measured and reported.

Reviewer 5:

The reviewer asked what the real benefit is of evaluating fuels in micro-liter quantities. NREL has been talking about alternate rating methods for RON and MON for years but to this reviewer's knowledge has not proposed anything yet.

The reviewer would like to know how NREL proposes to complement the AVL/Ford and Oak Ridge National Laboratory (ORNL) studies, and what advanced biofuels are being proposed for evaluation.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer found that this project is highly relevant to both improving fuel economy to meet higher mile per gallon targets, and reducing petroleum usage through implementation of alternative fuels.

Reviewer 2:

The reviewer said that the development of alternative experimental techniques such as the IQT to obtain fundamental kinetic information is very important to development of improved predictive tools needed for development of advanced combustion engines and fuels which support DOE goals.

Reviewer 3:

The reviewer commented that the project provides further insight into fuel properties and chemistry.

Reviewer 4:

The reviewer commented that this project is very relevant to the DOE objectives of petroleum displacement. The objective of the project, to address the technical barriers of inadequate data and tools for fuel and lubricant effects on advanced combustion engines, will in the long run help introduce advanced combustion engines into the market that will have higher fuel economy and help displace petroleum.

Reviewer 5:
The reviewer remarked that the project supports DOE mandate to reduce fossil fuel component from transport fuel.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer commented that resources appear sufficient, but barely so. The funding drop from 2014 to 2015 is unfortunate. The reviewer recommended that it would be wise to keep this program funded at its original request.

Reviewer 2:
The reviewer said that funds appear sufficient for research proposed.

Reviewer 3:
The reviewer remarked resources appear to be adequate for this project.

Reviewer 4:
The reviewer commented need funding for software/hardware to enable engine control independent of any original equipment manufacturer (OEM) support.

Performance of Biofuels and Biofuel Blends: Bob McCormick (National Renewable Energy Laboratory) - ft003

Presenter

Matt Ratcliff, National Renewable Energy Laboratory.

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commented that the approach covers much ground, fuels from a wide variety of feedstocks, from a variety of producers and for the range of applications (spark ignition [SI] and compression ignition [CI] engines). Considering conventional biofuels (first generation) and advanced biofuels from cellulose. The reviewer noted that through partnerships and outreach, covering a broad range of practical field work and laboratory studies.

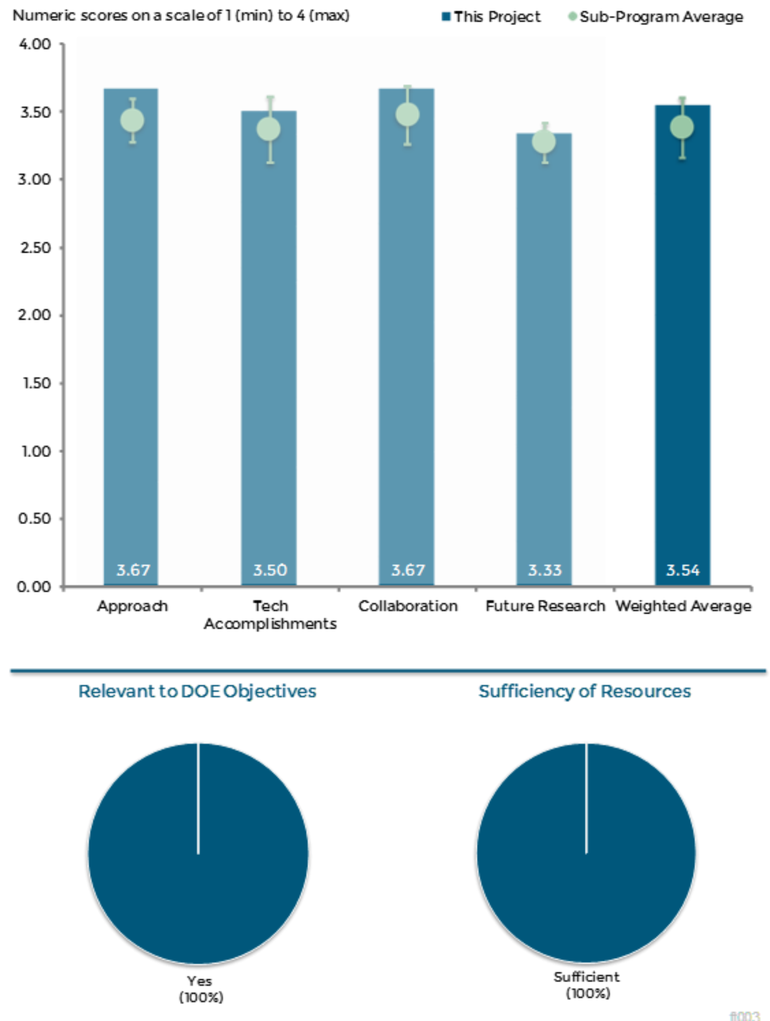


Figure 5-2 Performance of Biofuels and Biofuel Blends: Bob McCormick (National Renewable Energy Laboratory) – Fuel and Lubricant Technologies

Reviewer 2:

The reviewer noted as conventional approaches commercial samples – provides realistic look at practical issues. The research issues raised at American Society for Testing and Materials (ASTM) and Coordinating Research Council (CRC) contribute real world experiences. As advanced approaches, the reviewer noted employing industry standard tests, metrics for real world applicability.

Reviewer 3:

The reviewer remarked that conventional biodiesel work is being conducted in a very practical manner, as appropriate. The reviewer observed that lack of real samples for new fuels is hindering the research, but some progress is being made using model compounds.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer commented that the project explored the impact of alkali contaminants on emissions control systems. The project is comprehensively exploring the oxygenates that one could produce from cellulose. The reviewer remarked that this is a good concept, that the oxygen in the biomass-derived molecules should be used versus trying to drive all the oxygen out of pyrolysis oils, for instance. The reviewer enthused very interesting and valuable new results on 2,5-dimethylfuran (DMF) behavior in fuels.

Reviewer 2:

The reviewer commented it is a useful suggestion to not remove all oxygen from biofuels, however only studying model compounds will not uncover all the potential problems of this approach. The reviewer recommended that results should be presented with more certainty regarding new fuels, either our tests indicate that A is better than B and C is unsuitable, or, we recommend the following screening tests for new fuel compounds.

Reviewer 3:

Regarding the National Biodiesel Board (NBB) CRADA, the reviewer observed a very extensive dossier of information. About the oxygen content cost benefit, the reviewer made an interesting observation that it is not desirable commercially to completely hydrotreat out oxygen. Regarding the PMI versus oxygenate, the reviewer commented that this is very critical info for current auto/engine industry. The reviewer wondered if the statement “suggests no impact of fuel oxygen on particulate matter” contradicts prior research. The reviewer noted that the relationship of T90 to knock performance is interesting, but asked if it does not volatilize or burn completely, why does knock performance suffer. According to the reviewer, the answer to question was not satisfactory.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer found that for the biofuels aspect, great collaboration with general automotive, and the heavy-duty truck OEM industry. The cellulosic aspect displayed good collaboration.

Reviewer 2:

The reviewer observed good outreach over the years to the biofuels industry, and the team has made critically important contributions to shaping and improving the biodiesel industry. The project is helping the emissions control industry understand the impact of biofuels on deactivation and poisoning. The reviewer noted good university collaboration, and suggested that collaboration could expand to include other schools and research groups, via student visitors and interns.

Reviewer 3:

The reviewer commented very good long-term collaboration with NBB to keep the work focused on practical issues. According to the reviewer, a lack of collaboration with biofuel producers except an association level hinders research. The reviewer noted good collaborations with various associations, companies, and universities.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer commented work is planned to expand, continue and complete the ongoing efforts.

Reviewer 2:

The reviewer found that research is very applicable to current industry fuel/emission related issues.

Reviewer 3:
The reviewer suggested that if the project team is not removing all the oxygen from pyrolysis oil, there is a need to study problems with stability, gum, corrosion, cold flow, etc. Pure surrogate compounds will not duplicate all the effects.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer remarked that the project addresses achieving displacement of petroleum using biofuels.

Reviewer 2:
The reviewer found that expansion of knowledge about fuel chemistry, properties, and performance for new biofuels supports DOE goal of petroleum displacement.

Reviewer 3:
The reviewer noted that the presentation stated that the objective is 5% petroleum displacement per DOE's mandate.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer commented that it appears that the funding level is sufficient.

Reviewer 2:
The reviewer commented that the budget seems a little small to support both lab and engine work, so some more limited focus may be required.

Fuel Effects on Mixing-Controlled Combustion Strategies for High-Efficiency Clean-Combustion Engines: Chuck Mueller (Sandia National Laboratories) - ft004

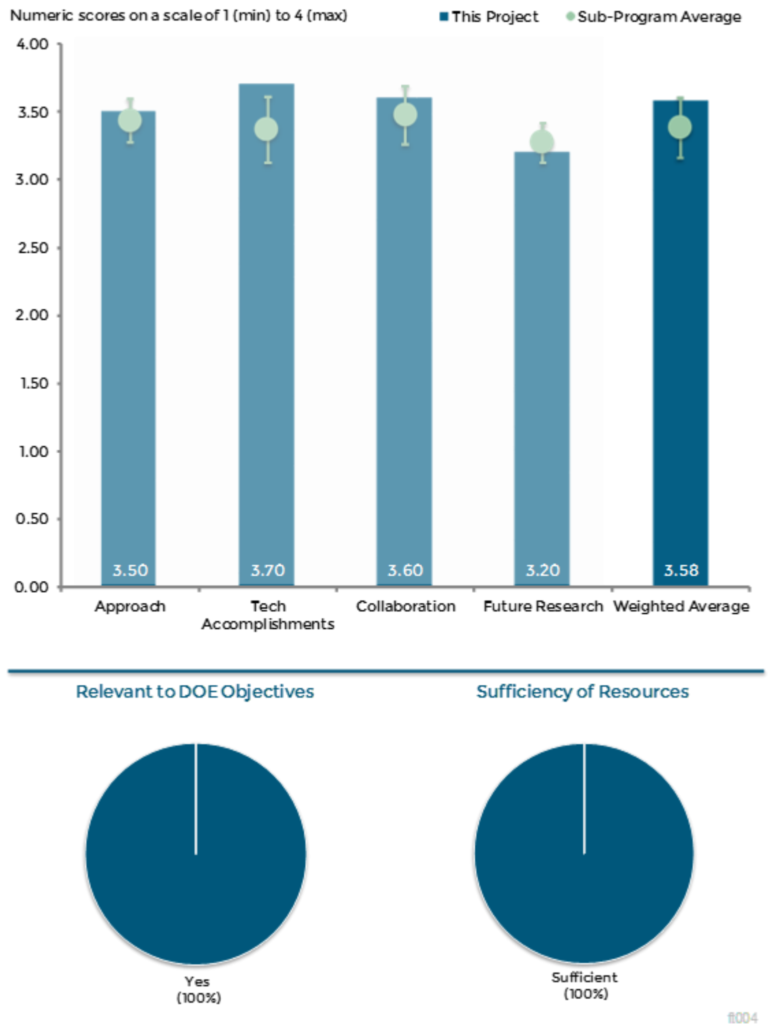


Figure 5-3 Fuel Effects on Mixing-Controlled Combustion Strategies for High-Efficiency Clean-Combustion Engines: Chuck Mueller (Sandia National Laboratories) – Fuel and Lubricant Technologies

Presenter

Chuck Mueller, Sandia National Laboratories.

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commented that a largely experimental approach is appropriate for studying fuels and combustion.

Reviewer 2:

The reviewer remarked that this optical engine facility and related facilities being used under the project are excellent, and abundant significant outcomes have been produced through these facilities. The project team provides uniquely authoritative results that have informed and improved many other researchers work over the years. The studies of lean lifted-flame combustion (LLFC) are well suited to this facility and the work has produced some significant outcomes, as are the soot measurements studies.

Reviewer 3:

The reviewer found that the approach to work on eliminating the barriers of inadequate and predictive tools for understanding fuel-property effects on combustion, engine efficiency and emissions is excellent. In addition, utilizing the unique and comprehensive diagnostic capabilities at the combustion research facility along with the collaboration with key stakeholders is an approach that has proven successful.

Reviewer 4:

The reviewer observed an excellent combination of industries (OEMs, fuels, engine manufacturers) with existing research.

Reviewer 5:

The reviewer applauded that generally the approach and focus areas are excellent. This program focuses on a number of key aspects that will advance knowledge and development of cleaner, high efficiency engines. The reviewer noted that this includes the collaborative work with CRC on development of diesel surrogate fuels; the development of an optical diagnostic to determine total in-cylinder soot mass; and the scoping work on a novel technique for mixing enhancement to improve the performance of the LLFC strategy (ducted fuel injection).

The one aspect of the work that did not make sense to the reviewer (and this reviewer therefore lowered the rating) is the testing of diesel fuels containing either 100% methyl decanoate or 50% tripropylene glycol methyl ether (TPGME) in the LLCF work. According to this reviewer, the probability is vanishingly low that either of these compounds would ever be commercially available in the quantities required for the transportation industry. Although theoretically the argument could be made that these compounds are just being tested as model compounds, work in this area has never progressed beyond those two compounds and there is no indication that that is the intent.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer observed that the project did an excellent job coordinating with the CRC project for diesel surrogate fuels. Soot measuring tool looks like it will be very useful. The reviewer observed interesting preliminary results for ducted fuel injection; need more results and in-depth data.

Reviewer 2:

The reviewer commented that there has been good technical progress this year in this project, including testing of improved diesel surrogate fuels and evaluated the use of oxygenated fuels to achieve LLFC. The reviewer observed that the milestones to fabricate hardware to evaluate ducted fuel injection concept and a paper summarizing results of testing methyl decanoate as a means to achieve LLFC have been met.

Reviewer 3:

The reviewer noted that the project has generated many papers and presentations. Very productive effort. The reviewer noted that the surrogate fuels work under this project can benefit the entire diesel fuels and engines community, so the potential for high impact is great. The LLFC work shows promise for defining how fuels can enable LLFC combustion. This is similar to prior work in this same facility (deemed Dilute Clean Diesel Combustion previously). The reviewer noted that fuel screening for LLFC can provide a significant step toward utilizing LLFC practically.

The reviewer remarked that the ducted injection studies are interesting, although they may be of limited practical value. It is unclear how this can be achieved in practice without greatly risking engine reliability.

Reviewer 4:

The reviewer described the ducted in-cylinder fuel injection concept as very intriguing, and recognized the potential breakthrough to load expansion of LLFC in conjunction with well managed injection timing. The reviewer also highlighted the possibility of minimizing particulate filters, increasing fuel economy by eliminating the need for regeneration, and adding net heating value (NHV) back in via aromatics. The reviewer observed the direct application to current engines, which could result in possible implementation sooner than homogeneous charge compression ignition (HCCI), RCCI, etc. Specific to the optical soot estimate, this reviewer suggested that a crank angle map can provide accurate feedback for injection strategies. The reviewer inquired as to whether the claim of specific oxygenates promoting zero smoke is applicable to the current crop of fatty acid methyl ester (FAME) fuels. With regard to the ducted fuel injection, the reviewer stated that the proof of concept needs follow-up with potential duct failure modes such as deposits.

Reviewer 5:

The reviewer observed excellent progress in the development of the surrogate diesel fuel formulations, the optical diagnostic tool to estimate total in-cylinder soot mass, and scoping of the novel idea of ducted fuel injection to improve the feasibility and performance of the LLFC concept. Future results on the engine testing of the diesel surrogates will be very interesting. However, according to the reviewer no effort has been made to move beyond unrealistic oxygenate blends containing 100% methyl decanoate or 50% TPGME for the LLFC concept.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer observed lots of collaboration with an energy company and automakers through the activities with the CRC, as well as with a heavy-duty OEM through a work-for-others project and with the other national laboratories.

Reviewer 2:

The reviewer commented that the collaboration and coordination continues to be very good. The guidance received on combustion research from the advanced engine combustion working group is valuable to the project especially because is it includes input from OEMs and energy companies as well as national laboratories and universities.

Reviewer 3:

The reviewer remarked CRC project collaboration with industry (OEM, oil companies, component manufacturers).

Reviewer 4:

The reviewer concluded that collaborations are good, and that more university involvement would be beneficial. Only listed university partner is Yale University through a National Science Foundation-DOE project. The reviewer commented that on each of the thrusts of this project, university partners could be engaged and expand the value for training and experience for students.

Reviewer 5:

The reviewer observed an excellent set of partners that is going beyond the combustion MOU. The reviewer asked is there further collaboration for ducted fuel injection. It would be good to know that someone believes it can work in a real engine.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer commented that the project will extend the surrogate work to engine studies – will help break the barrier to predictive simulation. The experimental plans are sound and should contribute to complete the project objectives.

Reviewer 2:

The reviewer commented that the proposed work on diesel surrogate fuels and the experiments identified to determine if LLFC can be sustained at higher loads with an oxygenated fuel seems to be appropriate.

Reviewer 3:

The reviewer anticipates that the matching of surrogate fuels with actual engine testing will be most revealing. Potential to take the burden off fuel design and transfer to mechanical design as technical solution to LLFC.

Reviewer 4:

The reviewer remarked that the proposed plans for the diesel surrogate fuels, soot model assessment, and continued assessment of the ducted fuel injection concept are excellent and should continue the progress made in those areas. However, according to the reviewer continued work on oxygenated diesel blends containing 50% TPGME or 100% methyl decanoate does not make any sense as those compounds have almost 0% probability of being manufactured on a commercial scale for the transportation industry. The lack of plans to focus on other oxygenates (such as biodiesel rather than just the one component of 100% methyl decanoate) suggests that the program investigators do not think that more realistic oxygenates will work.

Reviewer 5:

The reviewer commented that the researchers made claims for ducted fuel injection that should be better explained and verified (i.e., tolerance of higher aromatic fuels, use of lower injection pressure, and use lower cost after-treatment). The reviewer further remarked that it will be a good step of progress to move lifted flame to a six-hole nozzle, and it will be very useful to apply a soot tool to a variety of fuels and combustion situations to see how results can be applied.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer remarked that the project is highly relevant to DOE's mission: to improve efficiency and displace petroleum.

Reviewer 2:

The reviewer commented that the project expands knowledge of fuels, fuel mixing, and combustion.

Reviewer 3:

The reviewer found that the focus on various high efficiency, clean combustion engines and fuels is aligned with DOE objectives.

Reviewer 4:

The reviewer remarked that the project is very relevant to the DOE objective of petroleum displacement. Through the development of a science base that will enable cost-effective high-efficiency clean-combustion engines this project will help reduce fuel consumption.

Reviewer 5:

The reviewer commented that the project follows DOE mandate to promote energy security and petroleum displacement in transportation.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said that the funding is level and sufficient.

Reviewer 2:

The reviewer said the project team seems to be able to sustain progress in all areas undertaken with current resources.

Reviewer 3:

The reviewer said that the resources are sufficient to complete the project goals.

Advanced Lean-Burn DI Spark Ignition Fuels Research: Magnus Sjoberg (Sandia National Laboratories) - ft006

Presenter

Magnus Sjoberg, Sandia National Laboratories.

Reviewer Sample Size

A total of five reviewers evaluated this project.

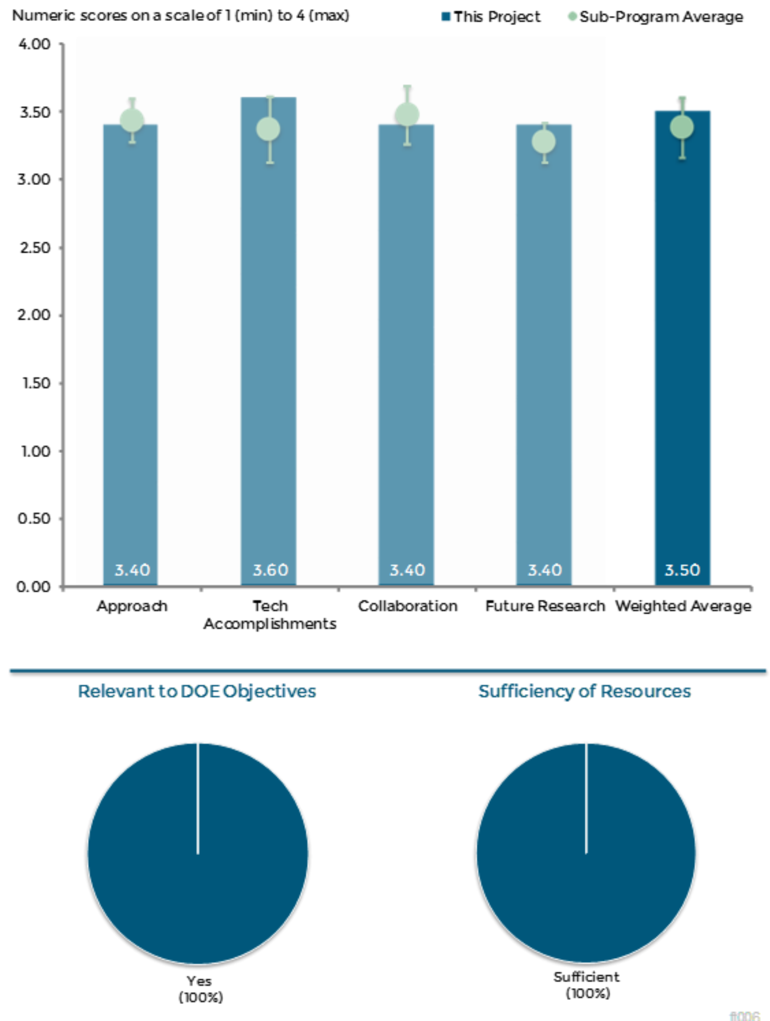


Figure 5-4 Advanced Lean-Burn DI Spark Ignition Fuels Research: Magnus Sjoberg (Sandia National Laboratories) – Fuel and Lubricant Technologies

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer found that the approach of progressing from metal engine to optical engine to modeling is a good way to conduct this research.

Reviewer 2:

The reviewer commented that the approach of combining experiments in optical and metal engines takes advantage of the benefits both platforms.

Reviewer 3:

The reviewer commented the approach of combining metal and optical engine experiments and modeling to develop a broad understanding of the impact of fuel properties on direct injection spark ignited (DISI) combustion has been successful. This approach addresses the barriers to high efficiency and low emissions by increasing the knowledge base and developing predictive models.

Reviewer 4:

The reviewer commented very appropriate given that the combustion modes are extensions of current SI engines with current and near-future fuels. Modelling combined with experiments to develop understanding. The reviewer commented applicable to current market engine (Mercedes-Benz) and upcoming OEM products.

Reviewer 5:

The reviewer commented that the project is considering both spray guided stratified combustion and dilute, lean well-mixed combustion to understand how fuels interact with these processes. This experimental facility is able to provide both fundamental insights and very practical knowledge via the optical access and ability to probe how structure of the burning mixture relates to performance and emissions. The reviewer remarked that focusing on ethanol blends for now is fine, and is responsive to national needs, but eventually, this activity should expand to include other practical (isobutanol) and emerging oxygenates. The reviewer commented supporting modeling through collaborations with individuals and national laboratories.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer noted that technical accomplishments in this project related to DISI with spray guided stratified charge combustion system and with well-mixed lean combustion system have been very good. In addition, diagnostic development to use flame spectroscopy to measure fuel stratification for E30 and gasoline was accomplished. The reviewer found that the project continues to meet the milestones specified.

Reviewer 2:

The reviewer commented very good progress in the two key project areas of spray-guided stratified charge DISI and well-mixed lean or dilute DISI. Accomplishments include: developed a conceptual model of spray-swirl interactions; performed initial mapping of ignition limited with regular spark system and role of autoignition for highly boosted stratified charge operation; particle image velocimetry showed repeatable flow is required for stable combustion; E0-E30 blends appeared compatible with highly efficient boosted stratified operation; for well-mixed lean or dilute DISI, the fuel economy gain is higher for E0 gasoline than for E30 and E85.

Reviewer 3:

The reviewer praised highly productive project that has potential for significant commercial impact. This project is expanding understanding of how to optimize the GDI combustion process and to leverage biofuels to enable higher efficiency. The reviewer observed a very interesting result that for lean combustion some amount of autoignition is needed for good combustion efficiency under ultra-dilute conditions. Obert mentioned in his textbook that optimal fuel economy requires mild knock (in vehicles of the 1960's and 1970's vintage of the time when Obert was writing and updating his text). The reviewer noted that HCCI operational broadening was demonstrated via spark assisted compression ignition in DOE-funded work. The reviewer asked what fraction of fuel needs to autoignite to ensure good combustion efficiency. The reviewer observed that the project demonstrated significant improvement in lean operation with multi-pulse spark approach.

Reviewer 4:

Regarding DISI spray guided, the reviewer noted E30 stratified combustion as an accomplishment. For DISI well mixed lean, the reviewer specified lean stability limits for E30, E85 and gasoline important information as OEMs push for higher oxygenate levels. The reviewer asked how deep into U.S. Environmental Protection Agency procedures (e.g., US06) is possible, lean and/or stoichiometric. Regarding the DISI swirl pattern, the reviewer noted key info that swirl stabilizes combustion indicated mean effective pressure (IMEP) coefficient of variance (COV). About lean boosted E30, the reviewer inquired about the effect of higher octane on end gas autoignition and whether octane from oxygenate functions differently than petroleum-based octane. The reviewer noted that exhaust gas recirculation (EGR) results in lower combustion stability, and asked is that load dependent or uniform across operating points. Regarding advanced ignition, the reviewer asked if there is any information on lean spark strategy versus cold start/deceleration fuel shut off conditions (air cooled combustion chamber).

Reviewer 5:

The reviewer acknowledged that all the results appear to be interesting and valuable, but according to the reviewer it is difficult to tie things together in a coherent picture because so many variables are being studied. The reviewer noted that the purpose of the project is to study fuel effects on combustion, but much of the results appear more engine related with only minor fuel variations. Variables being studied include lean versus stratified versus dilute, with and without enhanced ignition, and use of intake heat.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer remarked excellent collaborations for several aspects of the project.

Reviewer 2:

The reviewer observed several collaborations with OEMs (GM, Toyota, and the U.S. Council for Automotive Research [USCAR] Advanced Combustion and Emissions Control [ACEC]), and two universities.

Reviewer 3:

The reviewer commented that the project has excellent group of collaborators, including 15 industry partners in the AEC MOU, national laboratories, and universities.

Reviewer 4:

The reviewer noted excellent cross-functional collaboration, and specified GM, Tongji University, Sandia National Laboratories, USCAR, LLNL, and University of Michigan.

Reviewer 5:

The reviewer noted that through the AEC MOU, this project is connected to industry. The facility is supported by GM in the form of hardware (this project) and Toyota (non-VTO funds). But only two university connections are listed, through a Fulbright Scholar and a visitor, neither with a U.S. university. The reviewer identified this is the only significant weakness of the project. The reviewer asked if there are ways to connect with U.S. universities more extensively.

The reviewer reiterated that industry is involved (GM through providing hardware and Toyota through direct funding), but asked is there directly a customer for the outcomes from this work. The reviewer would like to know what the pathway is for technology transfer and implementation, apart from publication and presentation. This aspect still is not clear.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer commented that boosted E30 DISI stratified work is key information needed

Reviewer 2:

The reviewer commented that the planned work nicely builds on progress and advances program toward objectives.

Reviewer 3:

The reviewer noted that the project will continue the ongoing work on fuel, ignition hardware and combustion process, and suggested that it may be valuable to include studies of model fuels and gasoline surrogates to enhance understanding of how fuel formulation influences these combustion processes.

Reviewer 4:

The reviewer remarked that the future work identified, especially to continue studying effects of E0-E30 fuels on boosted stratified SI operation and to continue the collaboration on CFD and flame modeling, seems appropriate.

The reviewer commented end-gas autoignition—key for lean dilute combustion but how to simultaneously protect against knock but promote end-gas autoignition.

Reviewer 5:

The reviewer suggested that because this is a fuels project, it might be more useful to settle on a few fixed combustion strategies and then study a wider range of fuels.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer pointed out that this project focuses on both efficiency improvement and biofuel utilization. Thus the project is highly relevant to the DOE objective to displace petroleum.

Reviewer 2:
The reviewer commented that the project promotes the advancement of substitution of petrol with oxygenate.

Reviewer 3:
The reviewer remarked that the concept this project is exploring (advanced lean-burn DI) has the potential to significantly reduce fuel consumption and thus supports the DOE objective of reducing or displacing petroleum.

Reviewer 4:
The reviewer commented that this project is very relevant to DOE's goal of petroleum displacement. The project goals to provide the science base needed for determining fuel characteristics that enable current and emerging advanced combustion engines that are as efficient as possible will ultimately provide for a reduction in fuel consumption.

Reviewer 5:
The reviewer commented that the project is relevant for understanding advanced engine concepts, which could reduce petroleum consumption. The reviewer found that in current form, it is more of an ACE project rather than a fuels project.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer remarked that the funding is level and appears sufficient to support the project. However, according to this reviewer, this project has such potential for transition of insights into products in the field (fuel and engine) that increasing the budget would be wise in subsequent years.

Reviewer 2:
The reviewer commented sufficient resources for fuels progress shown.

Reviewer 3:
The reviewer confirmed that the resources appear to be sufficient to complete this project.

Fuel Effects on Emissions Control Technologies: Todd Toops (Oak Ridge National Laboratory) - ft007

Presenter

Todd Toops, Oak Ridge National Laboratory.

Reviewer Sample Size

A total of four reviewers evaluated this project.

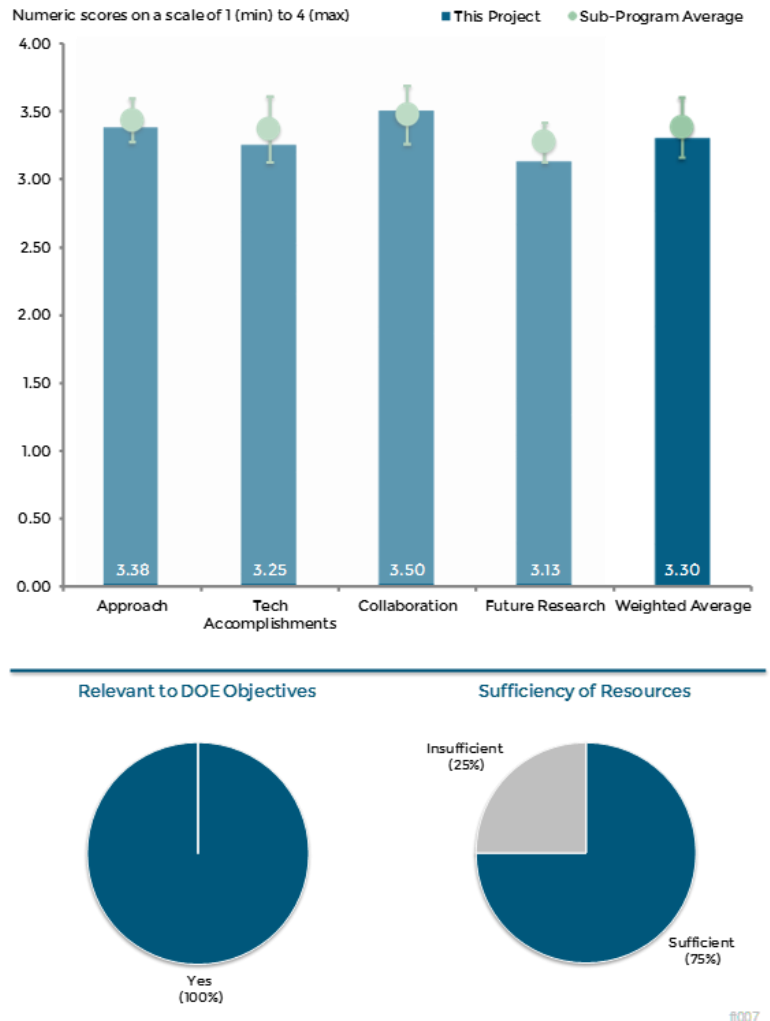


Figure 5-5 Fuel Effects on Emissions Control Technologies: Todd Toops (Oak Ridge National Laboratory) – Fuel and Lubricant Technologies

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer remarked that the project combines engine testing and validation of models to fully understand fuel and lubricant effects.

Reviewer 2:

The reviewer commented that the project is mainly experimental, with engine and bench experiments combined with materials analysis. This is a good approach for this type of work. The reviewer found that the project supports multiple independent subprojects, which broadens impact.

Reviewer 3:

The reviewer found that the approach of targeted, engine-based and flow reactor studies with in-depth characterization of particulate matter (PM), HCs and emissions control devices to better understand fuel and lubricant effects and interactions has proven to be successful.

Reviewer 4:

The reviewer acknowledged that the authors cover a lot of fundamental work, but questioned why each year a new sub-project is being started. The reviewer inquired if the authors can create two major subprojects: addressing gasoline/alcohol fuels and lubricants, and addressing diesel/biodiesel plus lubricants performance. This will help in setting/addressing technical goals.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer pointed out that technical accomplishments including confirming the potential for lean oxides of nitrogen (NO_x) control with ethanol blends, determining start-stop does not have a major impact on PM formation on E0 or E30, and showing fuel chemistry to have a significant effect on PM chemistry, have addressed the barriers of inadequate data on emissions. The reviewer noted that milestones continue to be met in a timely fashion.

Reviewer 2:

The reviewer observed that significant progress was made in assessing impact of alcohol containing gasoline fuels on NO_x controlling catalysts. No data was reported regarding exhaust and control of HC emissions. The reviewer also noted interesting fundamental data showing oxidative character of GDI PM. The reviewer commented no data reported on HD diesel catalyst performance.

Reviewer 3:

The reviewer pointed out that results referenced for dual selective catalytic reduction (SCR) are dated 2009, and asked if there are more current work available. The reviewer observed a good demonstration of ethanol lean NO_x catalyst, but no discussion of what level of conversion is actually needed or targeted. The reviewer noted interesting results about fuel effects on particulates and changes in activation energy (Ea) but no quantitative information about real effects on regeneration, just the qualitative statement "difficult or requiring more energy." The reviewer would like to know how much.

Reviewer 4:

Regarding lean NO_x control with ethanol, the reviewer noted silver alumina non-platinum group metal load, non-urea NO_x is critical pathway to combine oxygenate plus lean operation; higher HC still requires oxidizing catalyst. About this, the reviewer asked what the relative efficiency of HC addition versus HC savings in lean operation is. Furthermore, the reviewer asked how feasible is ammonia storage at high-load SS operation for lean NO_x mitigation. The reviewer also noted dual fuel membrane separation for reductant. Regarding GDI start-stop PM with biofuels, the reviewer noted that E30 is most reactive at lowest temperature for soot oxidation. The reviewer also inquired as to whether the trend follows for E85, and asked about the difference in fuel addition on soot burn-off cycle of oxygenate versus gasoline.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted excellent collaboration with other laboratories, universities, and industry. Lots of presentations and publications to share results.

Reviewer 2:

The reviewer observed that the project has a very comprehensive list of collaborators and partners including industry, national laboratories and universities.

Reviewer 3:

The reviewer noted as collaborators Shell, GM, Ford, Cummins, Manufacturers of Emission Controls Association (MECA), NBB, NREL, University of Michigan, and Chalmers University. The reviewer also observed industry, OEM, and academia support

Reviewer 4:

The reviewer pointed out a wide spectrum of collaborative organizations contributing to this project, and asked if most contributions are in-kind.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer commented that the plans for future research will continue to address the barriers identified in the project and will help to provide the necessary data to evaluate the impact of alternative fuels on emission control devices.

Reviewer 2:
The reviewer pointed out that for ethanol-lean NO_x, need to consider what levels of emissions conversions are actually needed and operation of system on lower ranges of ethanol content. The reviewer asked what if the driver chooses E0 or E10 all the time. Need some concrete results for membrane separation of ethanol.

The reviewer inquired can Ea and light-off differences between different soot be plugged into a soot filter regeneration model to estimate how much difference they will cause.

Reviewer 3:
The reviewer noted that durability effects on PM including sulfur and biodiesel production metals (sodium, potassium, etc.) are important to understand.

Reviewer 4:
The reviewer commented that there is no clear definition which subprojects will be completed sooner than others and inquired if all sub-projects have the same timeline and priority.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer said that understanding fuels/lubricants interaction is very complex phenomena and requires a lot of effort to provide guidance regarding its impact on fuel consumption.

Reviewer 2:
The reviewer pointed out that new or improved after-treatment is needed to enable new engines or fuels. The project directly supports that goal, and also provides a more in-depth picture of catalyst fundamentals, which can guide other researchers in the topic.

Reviewer 3:
The reviewer commented that this project supports the DOE objective of petroleum displacement by providing data on advanced combustion engines and alternative fuels that in the future will allow these advanced technologies to be used.

Reviewer 4:
The reviewer said that the project directly assesses oxygenate for gasoline and diesel as petrol displacement

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer commented that funding in 2015 has been reduced, while completion of proposed goals may require a lot of money, e.g., heavy-duty testing.

Reviewer 2:
The reviewer found that resources seem about right for this topic.

Reviewer 3:

The reviewer commented the resources provided for this project appear to be adequate.

Gasoline-Like Fuel Effects on Advanced Combustion Regimes: James Szybist (Oak Ridge National Laboratory) - ft008

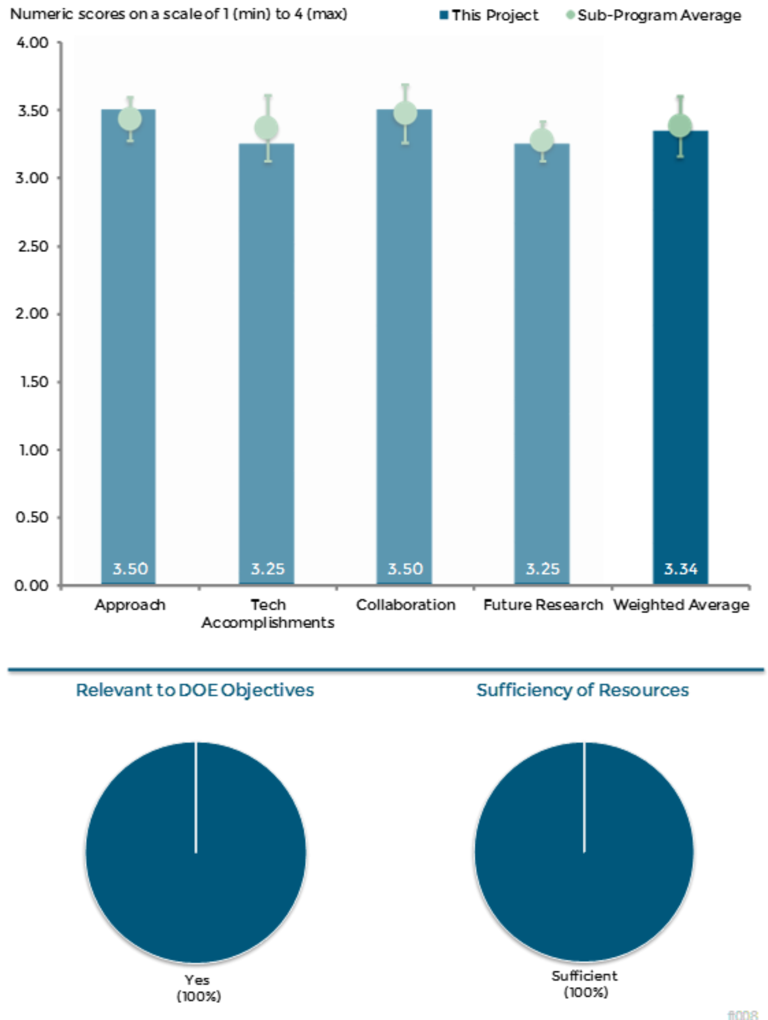


Figure 5-6 Gasoline-Like Fuel Effects on Advanced Combustion Regimes: James Szybist (Oak Ridge National Laboratory) – Fuel and Lubricant Technologies

Presenter

James Szybist, Oak Ridge National Laboratory.

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer found that the approach is very good, and remarked many important aspects of fuel effects on relevant combustion regimes and engine pathways are being studied in a relevant multi-cylinder engine.

Reviewer 2:

The reviewer noted that the project is a largely experimental approach to fuels research with emphasis on engine efficiency. The project is divided into three or four discrete topics with little coordination or overlap between them.

Reviewer 3:

The reviewer remarked that the EGR and high octane studies each attempt to quantify impact on combustion and efficiency. A combined study would be appropriate given that each study alone has issues, but in combination, they complement each other.

Reviewer 4:

The reviewer found that the approach of evaluating several different combustion strategies on the same base engine platform is excellent as it enables an apples-to-apples comparison. Also looking at the effects of fuel composition at a fixed RON level is valuable. The reviewer found that the work comparing the engine efficiency (brake thermal efficiency versus load brake mean effective pressure) for various fuel formulations is interesting, but should include testing of a high octane premium (91/92 anti-knock index [AKI] - 96/98 RON) E10, which is widely available in the market. The reviewer believed it is not fair to just compare the 101 RON E30 fuels with a 93 RON (presumably 87 AKI) E0 fuel.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer praised that a good amount of progress has been made. New information has been generated in three areas of interest, viz., knock-resistant fuel, dilution tolerant fuel, and low-temperature combustion fuel. The reviewer pointed out that the effect of fuel octane on engine efficiency and max load capability has been well known for a 100 years, but it is good to see the data in this study as expected in a modern relevant engine. The reviewer concluded that the effects of biofuels on the three areas are very interesting and encouraging.

Reviewer 2:

The reviewer noted that the focus on the ability to easily control combustion is important. According to the reviewer, the study of how the knock sensor affects engine timing and efficiency over a wide range of fuels is interesting and important, but the experiments may be pushing the engine control system into areas of operation that are not well developed. The reviewer observed that there is no detailed discussion of NO_x or PM, and asked as an example does NO_x go up with fuel stratification. The reviewer also remarked that each set of experiments have clear, easy to understand results and should be very useful in choosing between different fuel and combustion strategies.

Reviewer 3:

The reviewer noted very good progress in all three areas. The reviewer specifically pointed out the following: Demonstration that RCCI can meet 2020 ACEC stretch efficiency goal of 36% at 200 rotations per minute, 20% load; confirmation that the partial (low) fuel stratification approach has diesel-like efficiency, very low engine-out NO_x and soot emissions, but limited ability to control combustion phasing; and an interesting finding that at the nominal 97 RON level, the hydrocarbon (HC)-based fuel containing 30% toluene had lower tendency to knock than fuels containing 20% ethanol or 24% isobutanol. The reviewer noted that although one might be tempted to attribute the better performance to the slightly higher reported RON of the HC-based fuel (one unit higher than the fuels containing the oxygenates), at the nominal 91 RON level, the ethanol containing fuel had one RON higher value than the HC-based E0, but did not perform better. The reviewer presumed that octane effects on knocking prevention would be most important at the lower RON level.

Reviewer 4:

The reviewer inquired as to whether requiring high EGR to mitigate NO_x is the only solution to the highly stratified GCI challenge. Further, the reviewer asked if SCR or lean NO_x traps are plausible. Regarding the high-octane study, the reviewer asked what is the impact of revised piston geometry (to provide desired compression ratio [CR]) on fuel spray volatility and wall impingement, fuel pool fires, etc. The reviewer understands there are limitations in performing the experiment, but asked if these are significant considerations. The reviewer wondered does the conclusion that 13:1 CR marks an efficiency limitation imply that effective CR achieved through turbocharging also faces similar limitations. Regarding the reformate project, the reviewer observed very good info that the presence of carbon monoxide impacts IMEP COV, and that spark to 5% is the important metric.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer remarked it looks like an impressive list of partnerships and collaborations, and observed excellent engagement with industrial partners.

Reviewer 2:

The reviewer pointed out collaboration with the CRC, OEMs, and fuel providers, and that cross industry collaboration is obvious.

Reviewer 3:

The reviewer noted a significant amount of collaboration with industry (OEMs and energy companies), including collaboration with CRC.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer commented that the proposed future research looks to address some looming and existing concerns, and remarked excellent presentation overall.

Reviewer 2:

The reviewer commented plans are to continue progress.

Reviewer 3:

Regarding high-octane fuels for SI combustion, the reviewer recommended that cooled EGR, high-ignition energy, turbulence enhancement, and other means that industry is employing should be included in the study to see if efficiency and max-load capability can be further improved with higher compression ratios. The reviewer asked can the other possible effects (e.g., volumetric efficiency) of HOV be separated from its RON-like effects on knock. Any vehicle fuel economy estimations should include a downsized version with high output, and a rightsized version with high efficiency.

Regarding fuel effects on dilute combustion, the reviewer suggested that higher levels of EGR, high-ignition energy, optimal mixture motion, higher turbulence levels, etc., should be added in the plans so that the engine can operate at a state-of-the-art high level of dilution tolerance. The reviewer asked will the composition of the fuel have the same effects then.

Reviewer 4:

The reviewer remarked that studying reformate effects is not very useful unless ORNL has a way to generate reformate in a vehicle. The reviewer would like to know how ORNL intends to do this. There is a good progression of planning for each of the three topics. The reviewer noted that the focus on studying a wide range of realistic fuels to gain further understanding of chemistry effects is valuable.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer pointed out that the project studies interaction of fuels and combustion strategies relative to efficiency and stability, and that this topic is very relevant to DOE program goals.

Reviewer 2:

The reviewer said that the evaluation of fuel properties on performance of various advanced combustion strategies helps to identify the approaches which have the most promise for improving engine efficiency and lowering emissions, which are key DOE objectives.

Reviewer 3:

The reviewer commented that the project adheres to the DOE goal to reduce/replace petroleum in transportation fuel in the future.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said that resources appear sufficient, but may be split between too many separate projects.

Engine Friction Reduction Technologies: George Fenske (Argonne National Laboratory) - ft012

Presenter

George Fenske, Argonne National Laboratory.

Reviewer Sample Size

A total of four reviewers evaluated this project.

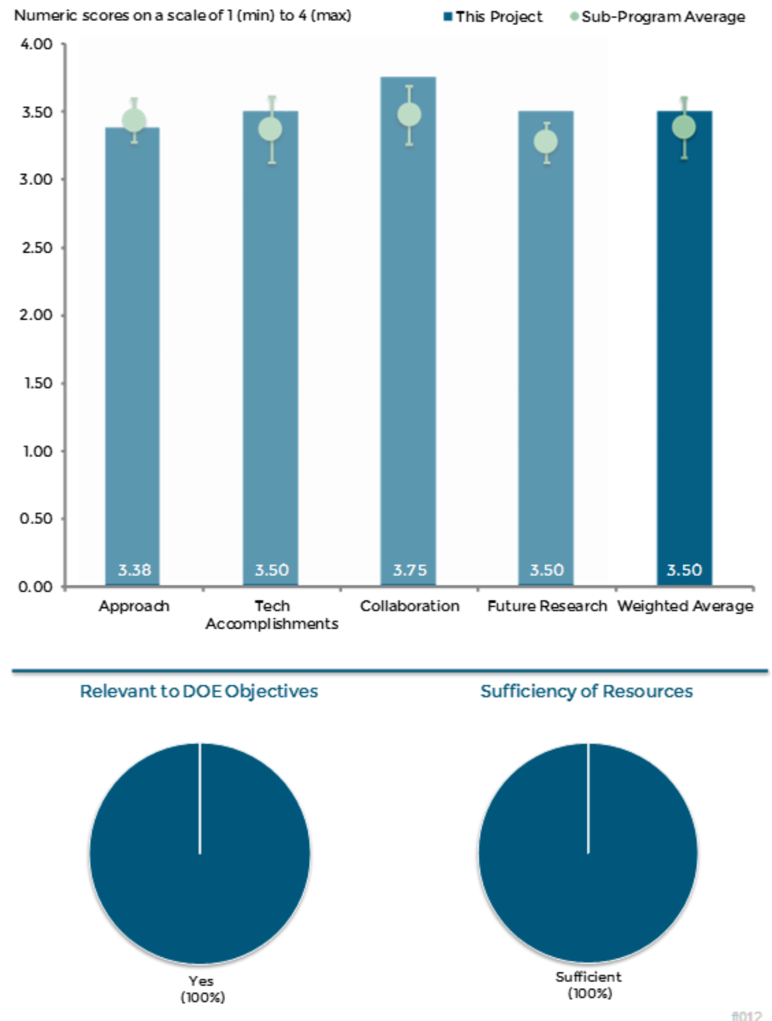


Figure 5-7 Engine Friction Reduction Technologies: George Fenske (Argonne National Laboratory) – Fuel and Lubricant Technologies

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commented that the project is mainly experimental work in the areas of tribofilm formation, test protocols, base fluids, additives, and coatings. This is a good focus when supplemented with surface analysis and some modeling.

Reviewer 2:

The reviewer observed an innovative approach using analytical instruments for tribofilm analysis. The project can potentially provide great fundamental tribology information.

The reviewer commented that benchtop testing correlative to effective fuel economy is a large technical risk; however, developing more standardized ways to quantify tribological performance is definitely a fruitful effort.

Reviewer 3:

The reviewer observed a good review of needs, technical barriers and currently conducted projects. However, no publication and presentations list was given. It is hard to judge how well findings are communicated among technical community. The reviewer recommended that national laboratories need to offer their contributions to technical community via presentations and publications.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer concluded that researchers have made good progress in all areas of research.

Reviewer 2:

The reviewer praised that innovative methodologies are being developed to analyze tribofilms. The reviewer noted that boundary lubrication (BL) additives and coatings to augment the Stribeck curve in the boundary lubrication regime is feasible with good preliminary results. The reviewer remarked that standardizing performance using proven and consistent benchtop test methodology is a must.

Reviewer 3:

The reviewer observed excellent progress in coatings area, especially in catalytically active coatings. The test protocols development area is moving forward nicely, although it still needs better description regarding what types of engine tests are being modeled and when publications on available data will be available to technical community. The reviewer is waiting to see a silver bullet being created in this area. The reviewer remarked that a side by side comparison of benefits of using Micro Xanes technique versus traditional surface analysis techniques could be a good addition to the data presented.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer detailed that academia, vehicle OEMs, engine OEMs, component OEMs, lubricant suppliers, additive suppliers, and small businesses are all involved in their respective areas of expertise. The project seems to be wide ranging, but well organized.

Reviewer 2:

The reviewer observed good participation and collaboration with OEMs, additive industries and other national laboratories. Participation in the Massachusetts Institute of Technology consortium adds extra value to predict critical frictional/wear/scuffing testing performance phenomena.

Reviewer 3:

The reviewer commented very good collaboration with industry with funding opportunity announcements (FOA) and CRADAs, and funds in research. ANL appears to be the go-to national laboratory for tribology research.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer is looking forward to future sets of excellent results. The reviewer recommended that the project team plan on publishing data in technical journals.

Reviewer 2:

The reviewer remarked that it would be nice to know more about the Ricardo engine model and how it could be accessed to support and verify other DOE funded research, in a similar manner to the GREET model for greenhouse gases. The reviewer sees a need to include some engine and vehicle modeling in order to predict how fundamental changes affect overall performance. The reviewer acknowledged that there is much hype about improving the legacy fleet with new lubricants. This should be demonstrated, including a study of durability, oil film thickness, and wear. The reviewer wonders how far we can really go.

Reviewer 3:

The reviewer’s only major concern lies within the correlation between benchtop testing and fuel economy equivalency. More applied component testing may alleviate some of the technical risk, but it is still a large barrier to overcome.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer said that investigating the fundamentals of tribology and state-of-the-art additives and coatings will enable the tailoring of lubricant, coating and additive package to the system, thus increasing fuel efficiency and supporting DOE objectives.

Reviewer 2:

The reviewer noted a good focus on critical gaps, and identified fundamental knowledge, bench test to real life tests correlations, development of novel techniques, etc.

Reviewer 3:

The reviewer commented that the project provides a potential for improving legacy fleet performance and new vehicles.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented it is critical that sufficient funds are provided in a future, so these important studies can continue to completion.

Reviewer 2:

The reviewer found that resources seem adequate to continue level of progress.

Reviewer 3:

The reviewer commented that considering the vast scope of this experimental work, the funding level seems appropriate.

Polyalkylene Glycol (PAG)-Based Lubricant for Light- and Medium-Duty Axles: Arup Gangopadhyay (Ford Motor Company) - ft023

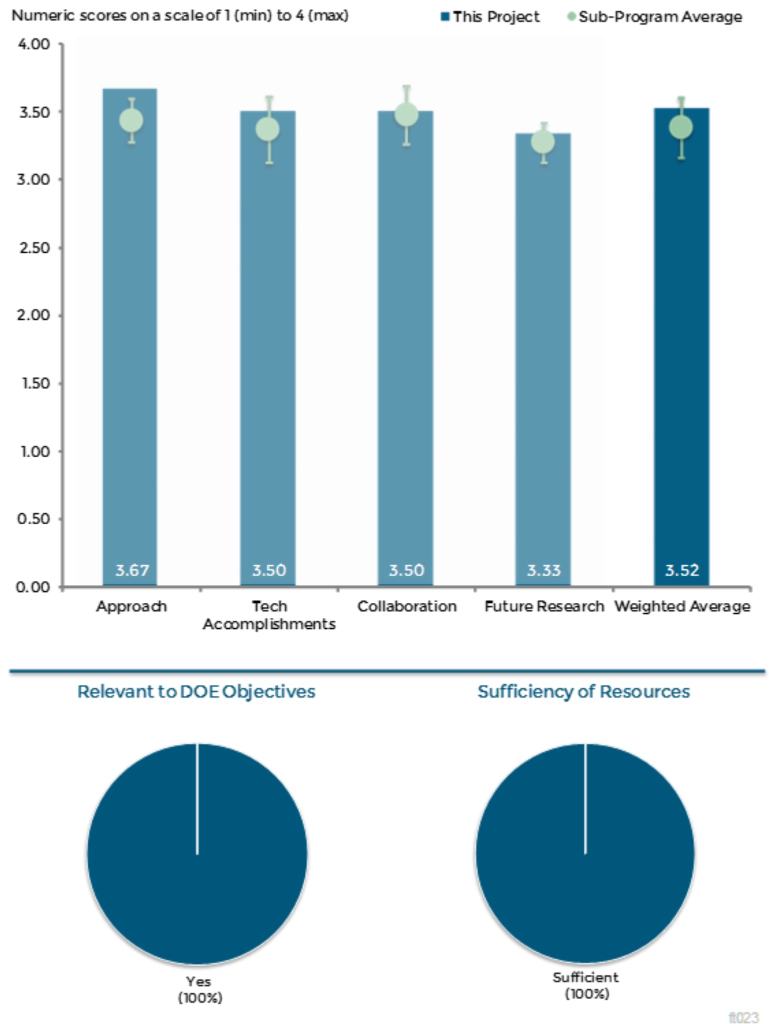


Figure 5-8 Polyalkylene Glycol (PAG)-Based Lubricant for Light- and Medium-Duty Axles: Arup Gangopadhyay (Ford Motor Company) – Fuel and Lubricant Technologies

Presenter

Arup Gangopadhyay, Ford Motor Company.

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commented that the project is a very practical approach to improving lubricants using standard tribology tests, bench tests, manufacturers' qualification tests, and full vehicle tests. It focuses on polyalkylene glycol (PAG) formulated base oils with additives for reducing axle and gear energy losses.

Reviewer 2:

The reviewer remarked candidate additive pack approach feasible. Selection of well-balanced additive pack to pursue with iterative additive levels. The reviewer observed a good mix of extreme pressure, friction and wear benchtop testing. The project can give an indication as initial screening but not for quantitative fuel economy gains, which will be addressed in future work.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer remarked that researchers have successfully selected base oils and additive package that provide targeted improvements and are now moving to optimizing and verifying the performance.

Reviewer 2:

The reviewer noted that the reported benchtop test data is incomplete, and that the baseline sample not thoroughly investigated (missing ball on disk friction and wear data to directly correlate with current best PAG candidates). The reviewer noted that wear and rippling appeared to be a problem in the L-37 testing, but the tested PAG 17-2 formulation was not the best performing candidate from preliminary benchtop testing. The reviewer remarked that testing candidates PAG 70-9 and/or PAG 71-5 (samples that performed better in all conducted bench tests) in L-37 could alleviate the wear and rippling issues without the need for ultimate reformulation.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted that the project team is leveraging Dow Chemical for PAG oil formulation, which is an absolute necessity. The reviewer remarked that ANL is a great selection for tribology testing and post-test tribofilm analysis via X-ray photoelectron spectroscopy (XPS) and Raman spectroscopy.

Reviewer 2:

The reviewer observed very useful teamwork with Dow for base fluids and with ANL for bench tests and characterization. The reviewer recommended that the project would definitely benefit from more direct involvement with an additive company, although the project team has access to some formulation variations.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer said that the project will be addressing a few performance problems uncovered as well as running full vehicle tests. This is a logical and appropriate plan.

Reviewer 2:

The reviewer pointed out that seal chemical compatibility is an immediate issue with PAG, which is being sufficiently addressed. Some of the preliminary datasets are currently incomplete but will be conducted in the near future. The reviewer would have liked to see the L-37 test conducted on the best PAG candidates instead of the baseline PAG formulation. Potentially that will be conducted in the future. The reviewer noted that superior wear protection of these candidates validated with benchtop testing could alleviate the wear and rippling exhibited in the PAG 17-2 L-37 testing. The reviewer suggested that the project team may want to investigate environmental properties because there is some potential for toxicity and biodegradability issues. The reviewer noted that friction data on the benchtop scale via ball on disc thus far, and it will be interesting to see block-on-ring, mini-traction machine (MTM) data, etc.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer commented that reducing energy losses in axles and gears can improve vehicle fuel economy.

Reviewer 2:

The reviewer opined that AG potentially has a place in the commercial market. A lot of technical barriers have to be addressed before such a technology can be implemented, many of which, are/will be addressed in the scope of this project.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented that resources appear adequate to achieve project goals.

Reviewer 2:

The reviewer found that there is sufficient funding for the scope of the project. DOE cost share was matched by the contractor, which illustrates the interest from the involved parties.

A Novel Lubricant Formulation Scheme for 2% Fuel Efficiency Improvement: Q. Jane Wang (Northwestern University) - ft024

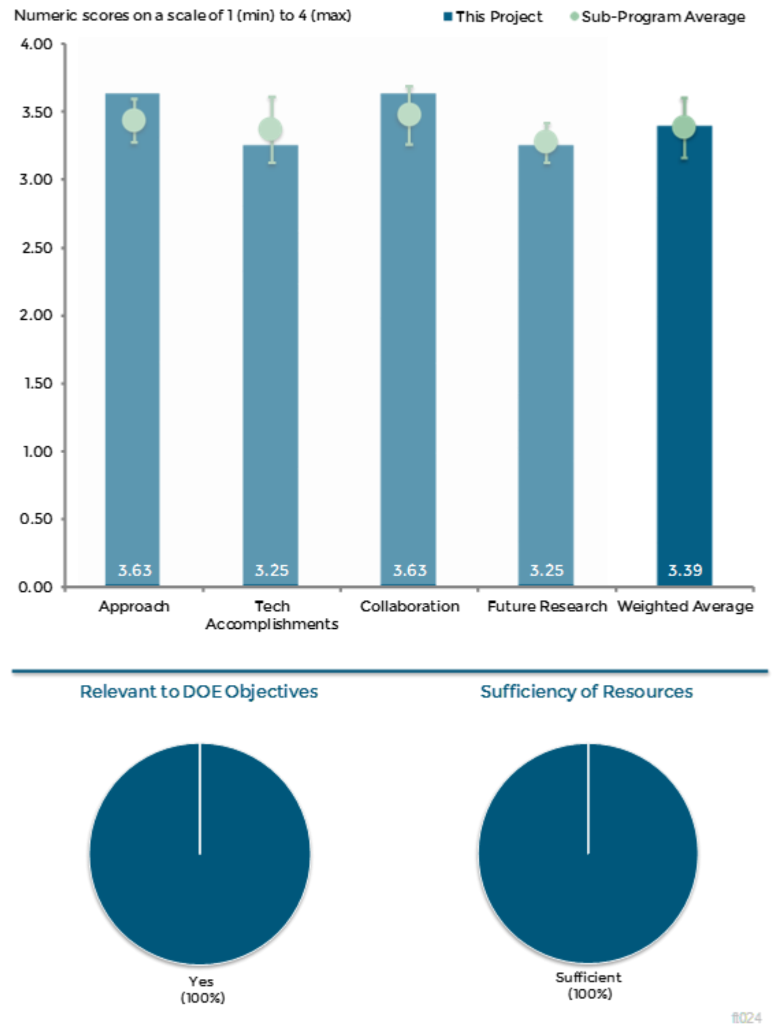


Figure 5-9 A Novel Lubricant Formulation Scheme for 2% Fuel Efficiency Improvement: Q. Jane Wang (Northwestern University) – Fuel and Lubricant Technologies

Presenter

Q. Jane Wang, Northwestern University.

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer noted that the project combines multiple approaches to friction reduction including heterocyclic additives, nanoparticles, and viscosity modifiers. This is a very complex experimental space, but needed for real world research.

Reviewer 2:

The reviewer opined that this is an important program addressing key knowledge needs expressed by the lubricants industry: balance between providing lower fuel consumption without negatively impacting hardware durability.

Reviewer 3:

The reviewer expressed some concern about integrating all of the novel lubricant additives together in a fully formulated lubricant, but this will be addressed in future work.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer found that progress appears good, advances were made in all three areas of friction reduction. The reviewer acknowledged that further work will be needed to formulate final lubricant and the balancing of additives to achieve desired result.

Reviewer 2:

The reviewer observed that the team has already demonstrated the technology feasibility of friction modifiers, viscosity improvers and nanoparticle additives individually against neat base stock. According to the reviewer, how the additives behave when introduced into a fully formulated lubricant has not been conducted yet, but will be addressed in near future work.

Reviewer 3:

The reviewer remarked that because this is a new project, there is insufficient data provided to judge progress made. The reviewer noted there is no data on novel viscosity modifier (VM) performance, and no wear assessments were provided. The reviewer would like to know if the reference oil, 5W-30, contains any friction modifier technology, and if yes, which type. The reviewer asked what validation engine tests will be performed, dyno or field trials. The reviewer asked what is the contribution of silicone particles to sulfate ash, and if there are any antagonistic interactions with exhaust catalysts. The reviewer asked if the new VM approach is actually totally novel technology, and if an intellectual property search was carried out.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted a great balance of academia and industry from premier groups, and good coordination between the several interested parties.

Reviewer 2:

The reviewer remarked that having Ashland and GM as a part of the technical team offers good leverage in guidance towards important industry needs.

Reviewer 3:

The reviewer observed a good set of partners for the collaboration, including GM, Ashland, and Argonne.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer said that goals are well defined. The reviewer is excited to see experimental performance results.

Reviewer 2:

The reviewer observed that the project is following logical progression: combining additives, transitioning to real base oils, and transitioning to fully formulated lubricants. The reviewer pointed out that durability of viscosity modifiers needs to be verified, and that additives need to be verified with other materials in addition to steel.

Reviewer 3:

The reviewer is concerned about the friction modifier and nanoparticle additive competition for surface area. A correlation may have to be developed to relate the effective area consumed by each representative additive unit acting on the metal surface and vary the ratio between these additives but leaving the additive total effective area coverage value constant. Thus, according to the reviewer an optimized ratio between friction modifiers and nano-additives could potentially be reached. The reviewer noted there is much interest in the analysis of the tribofilm generated from this proposed testing to investigate the surface chemistry complexity via XPS depth profiling, Raman, etc.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer said that proposed technologies could improve fuel economy and increase the robustness of the lubricant, both of which align well with the DOE objectives.

Reviewer 2:

The reviewer acknowledged a good alignment with DOE objectives.

Reviewer 3:

The reviewer said that reducing viscous and boundary friction with additives will improve vehicle fuel economy and may be retrofit-able to current vehicles.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said that funds are sufficient, and it is good to see Ashland's financial commitment.

Reviewer 2:

The reviewer found that resources should be sufficient to complete project and achieve goals.

Reviewer 3:

The reviewer pointed out that no cost added testing from interested parties enables a large scope of work at a feasible funding level.

Improve Fuel Economy through Formulation Design and Modeling: Gefei Wu (Ashland, Inc.) - ft025

Presenter

Gefei Wu, Ashland, Inc.

Reviewer Sample Size

A total of four reviewers evaluated this project.

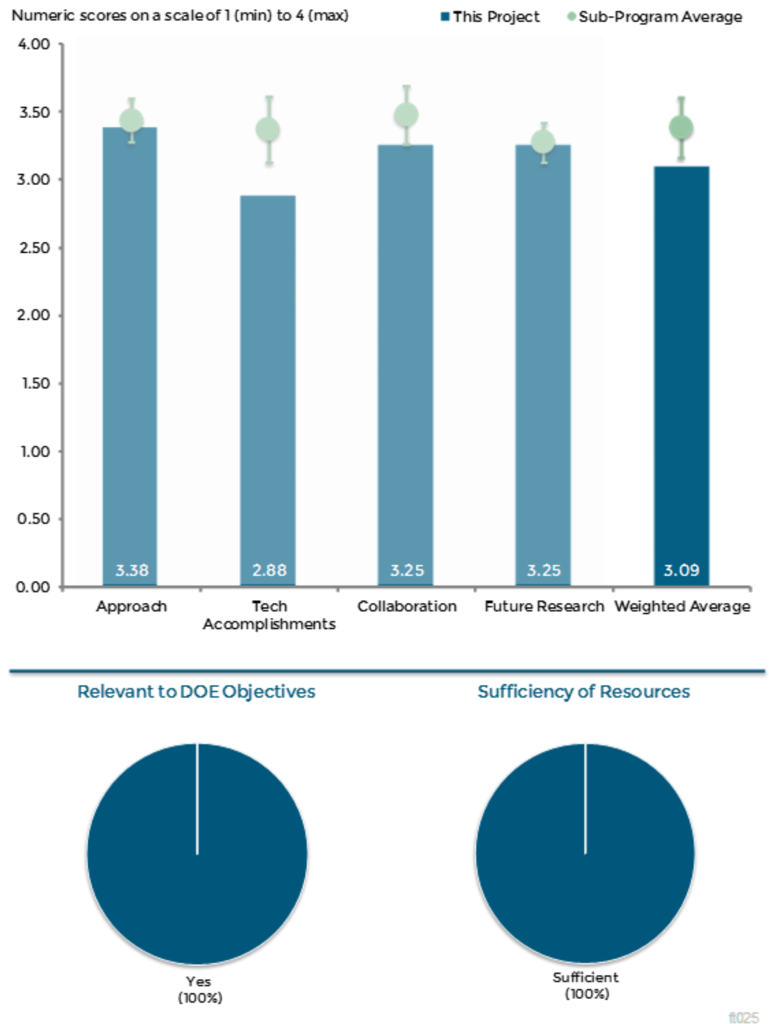


Figure 5-10 Improve Fuel Economy through Formulation Design and Modeling: Gefei Wu (Ashland, Inc.) – Fuel and Lubricant Technologies

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer is impressed with a holistic approach to assess fuel consumption by including performance contributions from engine oils, driveline fluids, and bearings.

Reviewer 2:

The reviewer observed a comprehensive approach of all three main lubrication requirements for a vehicle, engine, transmission, and axle. Use of in-house models to project results to vehicle should help with progress and selection. The reviewer asked is it realistic to compare new 5W oils to a 15W-40 baseline.

Reviewer 3:

The reviewer is concerned about the validity of the proprietary modelling. The reviewer asked if this model has been verified through previous research projects, and how correlative can this predictive model be expected.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer said that bench data and fluids selection process lack significant fundamental value, because authors do not share any information regarding formulation approaches used, modelling approach details or testing conditions, e.g., conditions for MTM traction data not given. Some delayed testing raises a concern for this reviewer about completing testing within expected timeline.

Reviewer 2:
The reviewer noted that the project has met goals for oil formulations but are behind on engine verification test. The reviewer asked when this is scheduled. The reviewer noted that the presentation gives very little information about the relative importance of viscosity versus additives for friction reduction.

Reviewer 3:
The reviewer found that modelling work shows promise but only addresses hydrodynamic lubrication. Boundary lubrication may prove to be a huge contributor to fuel economy. The reviewer noted that this will be addressed experimentally, but not through modelling.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer observe a good team of contributors selected.

Reviewer 2:
The reviewer noted a good combination of in-house research & development along with collaboration from Cummins, NREL, and additive suppliers.

Reviewer 3:
The reviewer observed a good balance of industry and national laboratory partners, and their respective capabilities have been properly utilized.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer found that the project is following the project plan as written, which should achieve desired results.

Reviewer 2:
The reviewer remarked that the authors need to timeline to complete all tasks on time.

Reviewer 3:
The reviewer said that experimental data are lacking in the current effort, but will be addressed in great detail in future research.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer pointed out that improved lubricants can improve fuel economy now, and that the project is aimed at existing engines rather than a future engine.

Reviewer 2:
The reviewer commented that the program addresses all DOE objectives.

Reviewer 3:
The reviewer concluded that reducing vehicle energy loss due to friction without sacrificing anti-wear performance aligns perfectly with DOE objectives.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said that the funding share is excellent on this project, which enabled an increased work scope.

Reviewer 2:

The reviewer concluded that resources should be sufficient to complete the research.

Reviewer 3:

The reviewer said that contributions from Ashland will help with conducting appropriate tests.

Developing Kinetic Mechanisms for New Fuels and Biofuels: Bill Pitz (Lawrence Livermore National Laboratory) - ft026

Presenter

Bill Pitz, Lawrence Livermore National Laboratory.

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

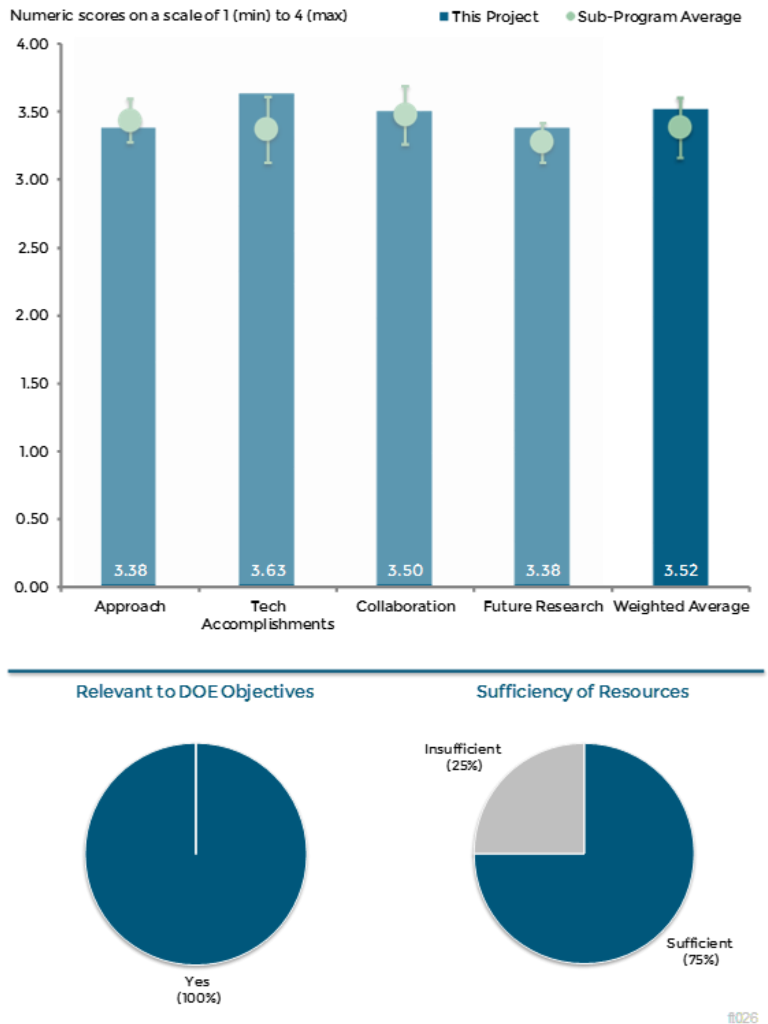


Figure 5-11 Developing Kinetic Mechanisms for New Fuels and Biofuels: Bill Pitz (Lawrence Livermore National Laboratory) – Fuel and Lubricant Technologies

Reviewer 1:

The reviewer applauded that this project is one of the few cases where the chemical kinetic, CFD, and experimental groups are working together in a cohesive way so that the total overall benefit is realized faster.

Reviewer 2:

The reviewer found that the project approach of developing several different tools (predictive chemical kinetics models, reduced mechanisms for improved CFD simulations, and equipment) to help identify fuel property/composition impacts on engine efficiency and emissions is a very good.

Reviewer 3:

The reviewer said that the project builds on a long successful history and methodology of mechanism development. Additionally, the project is beginning to acquire experimental tools for validation and calibration data.

Reviewer 4:

The reviewer observed a very thorough approach with chemical kinetic models both for practical and future fuels.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer said that several applications and experiments too numerous to mention have been targeted and simulated, and concluded very good progress.

Reviewer 2:

The reviewer found that the project is meeting milestones and deliverables. The project's reduced mechanisms and speed CFD calculations are publically available on LLNL's website. The reviewer pointed out that LLNL is providing CFD support for Sandia engines, which helps both programs.

Reviewer 3:

The reviewer found that the project is making excellent progress on meeting milestones, and specifically pointed out the following: Construction and initial testing of a micro fuel tester for ignition and extinction behavior and flame speed measurement; validating a surrogate model that can be used to obtain octane number correlations for gasoline surrogate fuels containing ethanol; evaluating burning velocities of a reference gasoline and E85 at conditions corresponding to spark timing in DISI engine; and from flame speed calculations, showed why higher intake temperatures improve combustion stability and efficiency for lean DISI.

Reviewer 4:

The reviewer said that micro-FIT is an important breakthrough to experimental fuel volumes/cost. Fuel fingerprints are a unique and novel analysis of fuels and properties, especially ignition delay time (IDT)/octane, and particularly ethanol/IDT quantification. Regarding burning velocity, the reviewer wonders why E85 flame speed is very close to gasoline. The reviewer's understanding is one of the functions of ethanol was higher flame speed. Regarding E85 stratified combustion, the reviewer would like to know what the lean limit is for combustion stability.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer pointed out a good relationship with Sandia for data and with the CRC for application of results. The reviewer also observed excellent partnering with several universities and national laboratories to obtain experimental data for developing and verifying mechanisms.

Reviewer 2:

The reviewer observed collaboration with an OEM and the energy industry through active participation in the CRC FACE Working Group, and collaborations with several universities and colleagues at the national laboratories. The project also allows their mechanisms to be available to the public through posting on their website.

Reviewer 3:

The reviewer said very good collaborations exist with advanced combustion work occurring in other laboratories.

Reviewer 4:

The reviewer observed very good industry collaboration through CRC, universities, laboratories, and OEMs.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer commented that plans will lead to wider applicability of the micro-FIT instrument and further development and improvement of gasoline surrogates.

Reviewer 2:

The reviewer recommended that continued micro-FIT is key for more easily performed research, at a lower cost. The end gas auto ignition research vital to better assess how much octane is enough and what is too much.

Reviewer 3:

The reviewer said that next year’s work is a good continuation of this year’s work, but recommended the number of topics may need to be limited to ensure sufficient depth of results.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer remarked that improved mechanisms allow simulation of combustion processes for better understanding and more efficient development of new fuels and engines. CFD modeling helps in understanding of experimental engine results and can be used to extend the studies.

Reviewer 2:

The reviewer found that the development of tools (predictive chemical kinetics models, reduced mechanisms for improved CFD simulations, and equipment) to help identify fuel property/composition impacts on engine efficiency and emissions supports DOE's objectives.

Reviewer 3:

The reviewer observed that the project provides models and understanding of the chemical kinetic behavior of fuels for advanced combustion concepts. The reviewer believed that this is much needed going forward.

Reviewer 4:

The reviewer said that the project overtly states that its goal is to quantify petroleum displacement with biofuels.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said that the budget appears to be sufficient to develop two or three topics per year. However, an increased budget could allow more in-depth studies and more modeling collaboration to be done. The reviewer said that it would be very valuable if LLNL could do more CFD modeling to support experimental programs at other national laboratories.

Unconventional and Alternate Fuels Research: Tim Bays (Pacific Northwest National Laboratory) - ft027

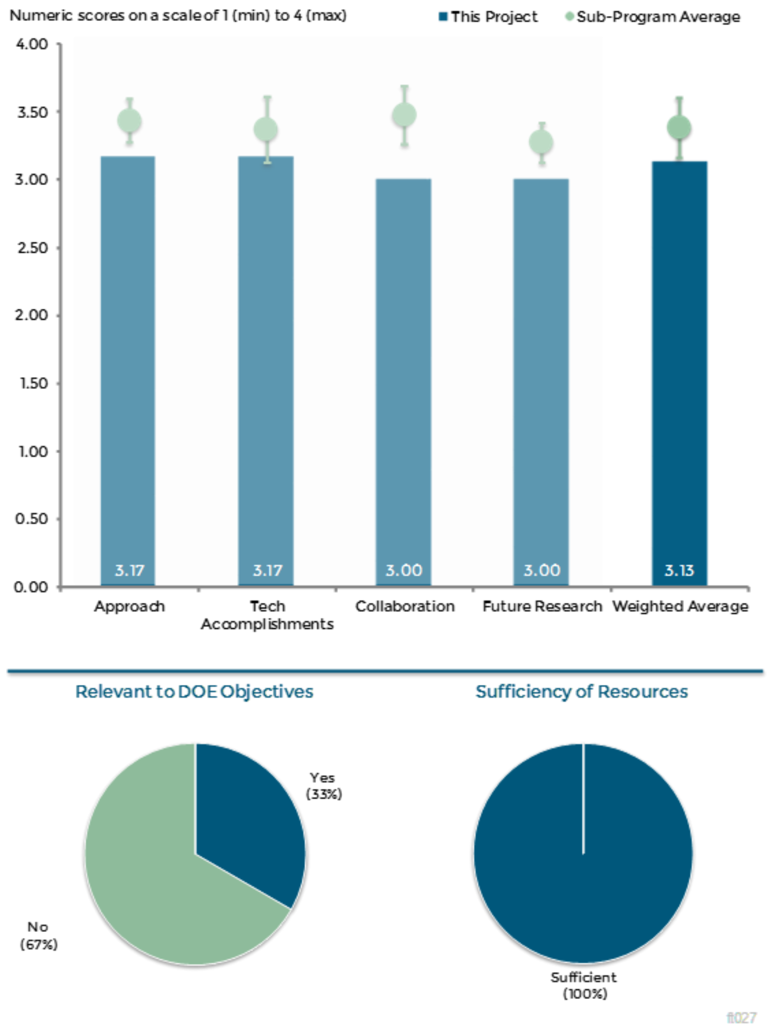


Figure 5-12 Unconventional and Alternate Fuels Research: Tim Bays (Pacific Northwest National Laboratory) – Fuel and Lubricant Technologies

Presenter

Tim Bays, Pacific Northwest National Laboratory.

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer found that given the objectives of this work – correlating fuel substructures to fuel properties – the approach is effective.

Reviewer 2:

The reviewer remarked that two-dimensional nuclear magnetic resonance (NMR) is a very appropriate tool for assessing carbon spectra, and that the application to real-world fuels and crudes is very timely. The reviewer said that predictive fuel characterization is a great upstream tool to assess and model fuel properties before resources are expended in the market and field issues arise.

Reviewer 3:

The reviewer detailed that this project has the objective of enabling better understanding of performance and compatibility impacts of fuels derived from unconventional HC resources. The deliverables will be detailed chemical analysis information, obtained with highly sophisticated techniques, and correlations of fuel properties based on these chemical analyses. The reviewer said that the approach is sound, but would be more comprehensive if it included experimental studies of fuel combustion and performance. The reviewer gathered that apparently this will be accomplished instead through connection with CRC working groups and CanmetENERGY.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer detailed that very valuable fuel chemical analyses are now being correlated to important fuel properties, such as lubricity. These results are valuable in and of themselves, but also may enhance understanding of how fuel sub-structures influence fuel properties. The reviewer concluded that this study could have far-ranging benefits beyond the focus of the project, and also noted that the project has generated publications and reports, with archival journal papers in preparation.

Reviewer 2:

The reviewer commented that shale oil characterization is important given the burgeoning U.S. market (tight oil, Marcellus shale). The reviewer remarked that the qualitative spectra (Complete Reduction to Amplitude Frequency Table [CRAFT]) is really an intriguing quantification of fuel makeup, and is similar to Fourier Transform digital signal processing in acoustics.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer said that it appears similar or related work at CRC and other organizations is recognized, and connections have been established.

Reviewer 2:

The reviewer pointed out that collaboration with CRC and CanmetENERGY represent very good collaboration with industry standard organizations.

Reviewer 3:

The reviewer pointed out that there is no university involvement, and acknowledged a connection to the larger community through CRC working groups.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer said that the project will be wrapping up by examining and completing fuel property correlations.

Reviewer 2:

The reviewer pointed out that CRAFT testing in representative fuels will be valuable to the success of CRAFT. The reviewer observed that the shale oil dataset is key information regarding potential fuel properties of the U.S. market.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer pointed out that the project’s stated objective is to reduce dependence on foreign resources.

Reviewer 2:

The reviewer detailed that by the wording of the question related to relevance, one must answer no. However, this project, by focusing on chemical and property characterization of unconventional fuels (historically this equals tar sand fuels, but now includes shale oil via fracking), this project can help in the process of displacing foreign (i.e., Organization of Petroleum Exporting Countries) oil. The reviewer observed that the project does not displace petroleum per se, and does not necessarily displace foreign oil, if one considers our major economic partner to the north, Canada, as being a problematic foreign petroleum supplier. The reviewer concluded that because strategically we differentiate between Canadian oil as foreign oil, the only concern with such oil resources is their carbon footprint.

Reviewer 3:

The reviewer noted that correlating fuel substructure properties to fuel properties for fuels from unconventional sources is probably very important. However, the reviewer found that the connection of this project to advanced combustion, high-efficiency engines is not clear. The reviewer asked on what basis were the test fuels chosen. It is not clear if the fuels chosen for characterization are good candidate fuels for low-temperature combustion or for some other type of advanced combustion concept. The reviewer pointed out that Slide Three refers to advanced combustion engines. The reviewer asked if it can it be made more specific as what these advanced combustion regimes are, and if it can be related to the U.S. DRIVE ACEC Roadmap, for example.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer found that resources seem sufficient.

Additive and Basefluid Development: Oyelayo Ajayi (Argonne National Laboratory) - ft029

Presenter

Oyelayo Ajayi, Argonne National Laboratory.

Reviewer Sample Size

A total of four reviewers evaluated this project.

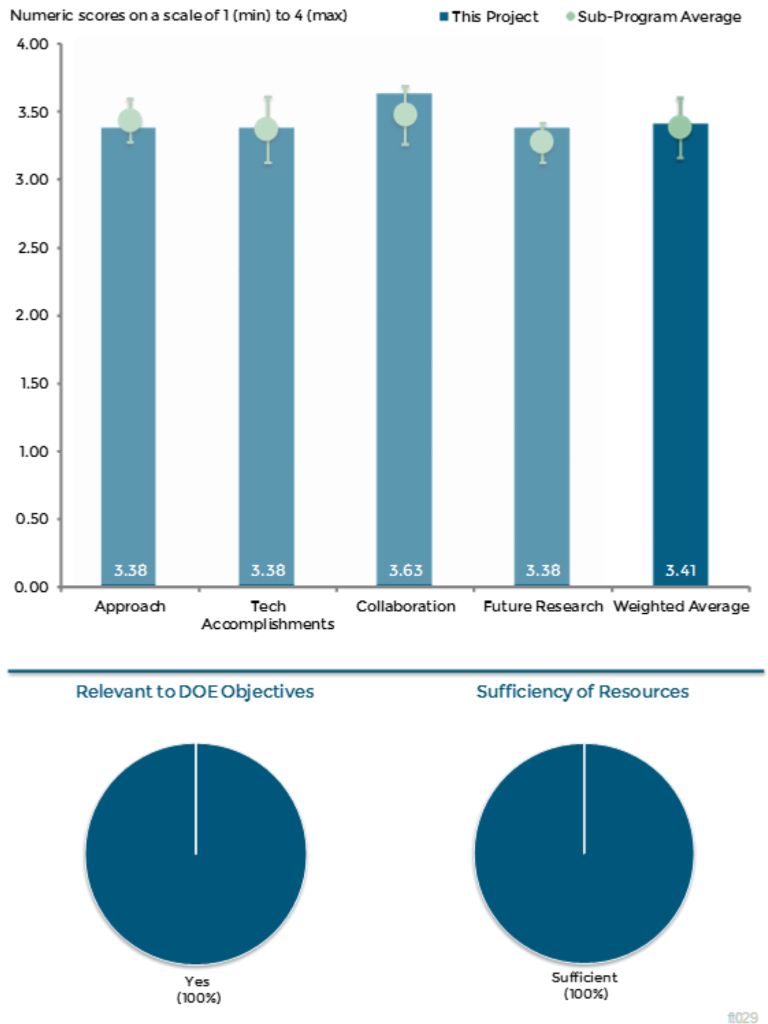


Figure 5-13 Additive and Basefluid Development: Oyelayo Ajayi (Argonne National Laboratory) – Fuel and Lubricant Technologies

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer observed an innovative approach using analytical instruments for tribofilm analysis, and that the project can potentially provide great fundamental tribology information.

Reviewer 2:

The reviewer commented that the program seeks to develop base oil and additive technologies using lab experimental techniques.

Reviewer 3:

The reviewer noted well-defined goals and technical barriers. However, there was no listing of patent/literature searches regarding studied base stock chemistries provided. The reviewer asked if the binary mixed matrix of base stocks studied is really a unique area to be examined. The reviewer would like to know what the actual chemistry is of the ester base stock studied.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer said the large scope of the project is covering a wide variety of state-of-the-art lubricants and lubricant additives. The project developed innovative methodologies to analyze tribofilms.

Reviewer 2:

The reviewer noted interesting work with encapsulates, but no physical evidence was presented to indicate that the particles are actually behaving according to the hypothesis/theory. The reviewer noted good progress with ester base fluids and solid lubricants, covering a broad range of oils and additives. The reviewer said that it is difficult to judge this project on its own because it lists the same budget and collaborators as other ANL lubricant projects.

Reviewer 3:

The reviewer noted interesting sets of friction reduction and wear control results. However, no description of ester chemistry was provided. The reviewer asked if it is unique or widely commercially available. The reviewer noted that colloidal dispersion work needs to include storage stability results. Oleic acid solutions are probably very corrosive towards copper and lead surfaces. The reviewer said that additional examination to control this phenomenon is needed.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer detailed that academia, vehicle OEMs, engine OEMs, component OEMs, lubricant suppliers, additive suppliers, and small businesses are all involved in their respective areas of expertise. The project seems to be wide ranging, but well organized.

Reviewer 2:

The reviewer observed good collaboration among various organizations.

Reviewer 3:

The reviewer noted an excellent group of collaborators through FOAs, CRADAs and funded research.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer identified a need to the combine technologies developed, and verify and evaluate performance in more complex tests. The reviewer observed that these lubricant combinations should also be screened for possible problems in the areas of corrosion, oxidation, water, and seal compatibility. The reviewer commented that it would be interesting to see images that show the encapsulated nanoparticles acting according to the theory (i.e., release as needed).

Reviewer 2:

The reviewer suggested including long-term (greater than three months) storage stability assessments, and including corrosion control assessments.

Reviewer 3:

The reviewer's only major concern lies within the correlation between benchtop testing and fuel economy equivalency. The reviewer cautioned that more applied component testing may alleviate some of the technical risk, but it is still a large barrier to overcome.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer found that investigating the fundamentals of tribology and state-of-the-art lubricants and additives will enable the tailoring of lubricant and additive package to the system, thus increasing fuel efficiency and supporting DOE objectives.

Reviewer 2:

The reviewer said that novel approaches to formulating future lubricants are needed by the industry. Fundamental understanding of tribofilm formation is a critical part in making significant progress.

Reviewer 3:

The reviewer said that the program provides a more fundamental understanding of additives and lubricants.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said that resources are sufficient for progress reported.

Reviewer 2:

The reviewer concluded that considering the vast scope of this experimental work, the funding level seems appropriate.

Acronyms and Abbreviations

AEC	Advanced Engine Combustion
AKI	Anti-knock index
ANL	Argonne National Laboratory
ASTM	American Society for Testing and Materials
BL	Boundary lubrication
CFD	Computational Fluid Dynamics
CI	Compression Ignition
CN	Cetane number
COV	Coefficient of variance
CR	Compression ratio
CRADA	Cooperative Research and Development Agreement
CRAFT	Complete Reduction to Amplitude Frequency Table
CRC	Coordinating Research Council
DCN	Derived cetane number
DISI	Direct Injection Spark Ignited
DMF	2,5-Dimethylfuran
DOE	Department of Energy
E0	0%t ethanol blend with gasoline
E10	10% ethanol blend with gasoline
E20	20% ethanol blend with gasoline
E30	30% ethanol blend with gasoline
E85	85% ethanol blend with gasoline
Ea	Activation energy
EGR	Exhaust Gas Recirculation
FACE	Fuels for Advanced Combustion Engines
FAME	Fatty acid methyl ester
FOA	Funding opportunity announcements

GCI	Gasoline compression ignition
GDI	Gasoline Direct Injection
HC	Hydrocarbon
HCCI	Homogeneous Charge Compression Ignition
HOV	Heat of vaporization
IDT	Ignition delay time
IMEP	Indicated mean effective pressure
IQT	Ignition quality tester
LLFC	Lean lifted-flame combustion
LLNL	Lawrence Livermore National Laboratory
LTC	Low-temperature combustion
MECA	Manufacturers of Emission Controls Association
MIT	Massachusetts Institute of Technology
MON	Motor octane number
MOU	Memorandum of Understanding
MTM	Mini-traction machine
NBB	National Biodiesel Board
NHV	Net heating value
NMR	Nuclear magnetic resonance
NOx	nitrogen oxides
NREL	National Renewable Energy Laboratory
OEM	Original equipment manufacturer
ORNL	Oak Ridge National Laboratory
PM	Particulate matter
PMI	Particulate matter index
RCCI	Reactivity controlled compression ignition
RON	Research octane number
SCR	Selective catalytic reduction

SI	Spark Ignition
TPGME	tri-propylene glycol methyl ether
VM	Viscosity modifier
VTO	Vehicle Technologies Office
XPS	X-ray photoelectron spectroscopy

6. Lightweight Materials

Advanced materials are essential for boosting the fuel economy of modern automobiles while maintaining safety and performance.

Because it takes less energy to accelerate a lighter object than a heavier one, lightweight materials offer great potential for increasing vehicle efficiency. Replacing cast iron and traditional steel components with lightweight materials such as high-strength steel, magnesium (Mg) alloys, aluminum (Al) alloys, carbon fiber (CF), and polymer composites can directly reduce the weight of a vehicle's body and chassis by up to 50% and therefore reduce a vehicle's fuel consumption. A 10% reduction in vehicle weight can result in a 6%-8% fuel economy improvement.

By using lightweight structural materials, cars can carry additional advanced emission control systems, safety devices, and integrated electronic systems without increasing the overall weight of the vehicle. While any vehicle can use lightweight materials, they are especially important for hybrid electric, plug-in hybrid electric, and electric vehicles. Using lightweight materials in these vehicles can offset the weight of power systems such as batteries and electric motors, improving the efficiency and increasing their all-electric range. Alternatively, the use of lightweight materials could result in needing a smaller and lower cost battery while keeping the all-electric range of plug-in vehicles constant.

Using lightweight components and high-efficiency engines enabled by advanced materials in one quarter of the U.S. fleet could save more than 5 billion gallons of fuel annually by 2030.

The U.S. Department of Energy (DOE) Vehicle Technologies Office (VTO) collaborates with industry to improve materials that will increase vehicle efficiency while meeting consumer and industry expectations. It does this through work on both Lightweight Materials and Propulsion Materials. In the case of Lightweight Materials, VTO works to lower the cost and improve the properties of lightweight materials while maintaining safety, comfort, reliability, performance, recyclability, and cost.

Research and development is done in collaboration with industry, national laboratories, and universities. VTO contributes to the Materials Genome Initiative, a federal interagency effort to support Integrated Computational Materials Engineering. It also works through government/industry partnerships:

- The U.S. DRIVE Partnership focusing on light-duty vehicles
- The 21st Century Truck Partnership, focusing on heavy-duty vehicles
- The US Automotive Materials Partnership (USAMP).

The Lightweight Materials subprogram’s major R&D goal by 2015 is to validate the ability to reduce the weight of a passenger vehicle body and chassis system by 50% compared to a 2002 vehicle. This reduction needs to be cost-effective and the materials need to be recyclable as well.

Subprogram Feedback

DOE received feedback on the overall technical subprogram areas presented during the 2015 Annual Merit Review (AMR). Each subprogram technical session was introduced with a presentation that provided an overview of subprogram goals and recent progress, followed by a series of detailed topic area project presentations.

The reviewers for a given subprogram area responded to a series of specific questions regarding the breadth, depth, and appropriateness of that DOE VTO subprogram's activities. The subprogram overview questions are listed below, and it should be noted that no scoring metrics were applied. These questions were used for all VTO subprogram overviews.

Question 1. Was the program area, including overall strategy, adequately covered?

Question 2. Is there an appropriate balance between near- mid- and long-term research and development?

Question 3. Were important issues and challenges identified?

Question 4. Are plans identified for addressing issues and challenges?

Question 5. Was progress clearly benchmarked against the previous year?

Question 6. Are the projects in this technology area addressing the broad problems and barriers that the Vehicle Technologies Office (VTO) is trying to solve?

Question 7. Does the program area appear to be focused, well-managed, and effective in addressing VTO's needs?

Question 8. What are the key strengths and weaknesses of the projects in this program area? Do any of the projects stand out on either end of the spectrum?

Question 9. Do these projects represent novel and/or innovative ways to approach these barriers as appropriate?

Question 10. Has the program area engaged appropriate partners?

Question 11. Is the program area collaborating with them effectively?

Question 12. Are there any gaps in the portfolio for this technology area?

Question 13. Are there topics that are not being adequately addressed?

Question 14. Are there other areas that this program area should consider funding to meet overall programmatic goals?

Question 15. Can you recommend new ways to approach the barriers addressed by this program area?

Question 16. Are there any other suggestions to improve the effectiveness of this program area?

Responses to the subprogram overview questions are summarized in the following pages. Individual reviewer comments for each question are identified under the heading Reviewer 1, Reviewer 2, etc. Note that reviewer comments may be ordered differently; for example, for each specific subprogram overview presentation, the reviewer identified as Reviewer 1 in the first question may not be Reviewer 1 in the second question, etc.

Subprogram Overview Comments: Will Joost (U.S. Department of Energy) - lm000

Question 1: Was the program area, including overall strategy, adequately covered?

Reviewer 1:

The reviewer said that the overall strategy for materials was well identified, particularly the Materials Technology Gap Priorities slide. However, the reviewer did not see propulsion represented in this slide, only the lightweight materials. The reviewer recommended a similar prioritization be shown for the propulsion technologies, and also recommends showing a clearer breakdown of which items are higher priority.

Question 2: Is there an appropriate balance between near- mid- and long-term research and development?

Reviewer 1:

The reviewer said that the presentation gave a good overview of the challenges that the materials team is facing and some of the research and development, but delegated much of the explanation of the research and development to the individual project presentations. The reviewer recommended that it would have been clearer showing how the projects are linked into stated project goals instead of a list of projects explaining what the projects are currently doing.

Question 3: Were important issues and challenges identified?

Reviewer 1:

The reviewer said that key challenges were explained and summarized well.

Question 4: Are plans identified for addressing issues and challenges?

Reviewer 1:

The reviewer said that the roadmap addresses many of the challenges and the plans to address them.

Question 5: Was progress clearly benchmarked against the previous year?

Reviewer 1:

The reviewer did not see a clear comparison to the previous year. The highlights shown gave some indication, but the few shown did not mirror the breadth of projects.

Question 6: Are the projects in this technology area addressing the broad problems and barriers that the Vehicle Technologies Office (VTO) is trying to solve?

Reviewer 1:

The reviewer said that the projects are addressing broad problems and barriers.

Question 7: Does the program area appear to be focused, well-managed, and effective in addressing VTO's needs?

Reviewer 1:

The reviewer said that the program appears well focused and managed tactically, but the broader strategic goals and timeframe to accomplish the goals were not shared.

Question 8: What are the key strengths and weaknesses of the projects in this program area? Do any of the projects stand out on either end of the spectrum?

Reviewer 1:

The reviewer said that the overall plan, particularly for lightweight materials, seems to be an all of the above strategy. The reviewer expects that eventually there will be a drive to down-select some of the alloy categories, but the reviewer agrees that would be premature at this stage. The reviewer said that one strength of this program is that the projects under this program area appear to be high risk/high reward, and that one weakness is while both the lightweighting and propulsion sub-programs contain a computational or integrated computational modeling (ICME) approach, the projects seem to be separate, rather than integrated or weaved into existing programs.

Question 9: Do these projects represent novel and/or innovative ways to approach these barriers as appropriate?

Reviewer 1:

The reviewer said that there is insufficient information to evaluate if the approaches are novel or innovative.

Question 10: Has the program area engaged appropriate partners?

Reviewer 1:

The reviewer said that the program seems well-integrated into federally funded research centers, industrial and academic partners.

Question 11: Is the program area collaborating with them effectively?

Reviewer 1:

The reviewer said that the program has done a good job of facilitating interaction between these groups.

Question 12: Are there any gaps in the portfolio for this technology area?

Reviewer 1:

The reviewer sees a few gaps. The reviewer asked what materials beyond Mg and CF composite will be needed to reduce weight beyond 37%, and how are predictive models shared and/or translated from academic to industrial use.

Question 13: Are there topics that are not being adequately addressed?

Reviewer 1:

The reviewer said that it is difficult to assess if topics are not being adequately addressed. The program area is very broad, and there will always be tradeoffs on what can be accomplished with limited funding.

Question 14: Are there other areas that this program area should consider funding to meet overall programmatic goals?

Reviewer 1:

The reviewer pointed out that there are still a number of challenges in Al and steel that are unaddressed and sparsely represented in the projects, as well as materials for glazings and other car components that could be used to lightweight the vehicle.

Question 15: Can you recommend new ways to approach the barriers addressed by this program area?

Reviewer 1:

The reviewer said that overall, the program area seems well aligned to deal with many of the barriers.

Question 16: Are there any other suggestions to improve the effectiveness of this program area?

Reviewer 1:

The reviewer said that it is difficult to evaluate the effectiveness of the program area with the information provided.

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.

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Advanced Oxidation and Stabilization of PAN-Based Carbon Precursor Fibers	Paulauskas, Felix (ORNL)	6-9	3.33	3.33	2.83	2.83	3.21
Scale-Up of Magnesium Production by Fully Stabilized Zirconia Electrolysis	Powell, Adam (INFINIUM, Inc.)	6-11	3.50	3.38	3.00	3.25	3.34
Mechanistic-Based Ductility Prediction for Complex Magnesium Castings	Sun, Xin (PNNL)	6-15	3.63	3.50	3.63	2.88	3.47
Multi-Material Lightweight Vehicles	Skszek, Tim (Vehma)	6-18	4.00	3.67	3.83	3.67	3.77
SPR Process Simulation, Analyses, and Development for Magnesium Joints	Stephens, Elizabeth (PNNL)	6-21	3.00	3.00	3.17	3.00	3.02
Understanding Protective Film Formation by Magnesium Alloys in Automotive Applications	Brady, Mike (ORNL)	6-23	3.00	2.83	2.67	2.83	2.85
Magnesium-Intensive Front End Sub-Structure Development	Quinn, Jim (United States Automotive Materials Partnership)	6-26	4.00	4.00	3.83	3.67	3.94

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Aluminum Formability Extension through Superior Blank Processing	Sun, Xin (PNNL)	6-29	3.50	3.50	3.50	2.50	3.38
Enhanced Room-Temperature Formability in High-Strength Aluminum Alloys through Pulse-Pressure Forming	Davies, Rich (PNNL)	6-32	3.33	3.17	3.33	3.00	3.21
Integrated Computational Materials Engineering Approach to Development of Lightweight 3GAHSS Vehicle Assembly	Hector, Lou (United States Automotive Materials Partnership)	6-34	3.75	3.25	3.75	3.13	3.42
GATE Center of Excellence at UAB for Lightweight Materials and Manufacturing for Automotive, Truck and Mass Transit	Vaidya, Uday (Univ Alabama Birmingham)	6-37	3.00	3.25	3.50	2.88	3.17
Validation of Material Models for Automotive Carbon Fiber Composite Structures	Berger, Libby (GM)	6-41	3.25	2.88	3.63	2.88	3.06
Collision Welding of Dissimilar Materials by Vaporizing Foil Actuator	Daehn, Glenn (Ohio State University)	6-44	3.50	3.67	3.00	3.17	3.48
Active, Tailorable Adhesives for Dissimilar Material Bonding, Repair and Assembly	Haq, Mahmood (Michigan State University)	6-46	3.00	3.17	2.50	3.00	3.02

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
High-Strength Electroformed Nanostructured Aluminum for Lightweight Automotive Applications	Ruan, Shiyun (Xtalic Corporation)	6-49	2.88	3.00	2.75	3.00	2.94
Technical Cost Modeling for Vehicle Lightweighting	Mascarin, Tony (IBIS Associates)	6-53	3.13	3.00	3.00	2.63	2.98
Phase Transformation Kinetics and Alloy Microsegregation in High-Pressure Die Cast Magnesium Alloys	Allison, John (U of Michigan)	6-56	3.50	3.38	3.25	3.38	3.39
In-Situ Investigation of Microstructural Evolution During Solidification and Heat Treatment in a Die-Cast Magnesium Alloy	Rohatgi, Aashish (PNNL)	6-59	3.13	2.75	3.00	3.13	2.92
High-Throughput Study of Diffusion and Phase Transformation Kinetics of Magnesium-Based Systems For Automotive Cast Magnesium Alloys	Lou, Alan (Ohio State University)	6-62	3.63	3.50	3.25	3.50	3.50
Microstructure and the Corrosion/Protection of Cast Magnesium Alloys	Sieradzki, Karl (Arizona State University)	6-65	3.33	3.50	2.67	2.83	3.27

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
A System Multiscale Modeling and Experimental Approach to Protect Grain Boundaries in Magnesium Alloys from Corrosion	Horstemeyer, Mark (Mississippi State University)	6-68	3.50	3.50	1.67	3.17	3.23
Corrosivity and Passivity of Metastable Magnesium Alloys	Song, Guang-Ling (ORNL)	6-70	3.33	3.17	2.67	3.00	3.13
Laser-Assisted Joining Process of Aluminum and Carbon Fiber Components	Sabau, Adrian (ORNL)	6-73	3.13	3.13	3.00	2.75	3.06
Brazing Dissimilar Metals with a Novel Composite Foil	Weihs, Tim (Johns Hopkins University)	6-76	3.17	3.17	2.83	3.00	3.10
High Strength, Dissimilar Alloy Aluminum Tailor-Welded Blanks	Hovanski, Yuri (PNNL)	6-78	3.83	3.83	3.83	3.83	3.83
Upset Protrusion Joining Techniques For Joining Dissimilar Metals	Logan, Steve (Fiat Chrysler Automobiles US LLC)	6-80	3.17	3.67	3.17	3.50	3.46
Overall Average			**3.37**	**3.32**	**3.13**	**3.09**	**3.28**

Advanced Oxidation and Stabilization of PAN-Based Carbon Precursor Fibers: Felix Paulauskas (Oak Ridge National Laboratory) - lm006

Presenter

Felix Paulauskas, Oak Ridge National Laboratory.

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer said that the targeted approach on a specific portion of the process is good. However, the reviewer also said the carbon fiber (CF) program seems to lack an overall approach to achieve commercial application (cost and cycle time) and environmental barriers. The reviewer commented that where we are and where we are going seem to be unknown entities.

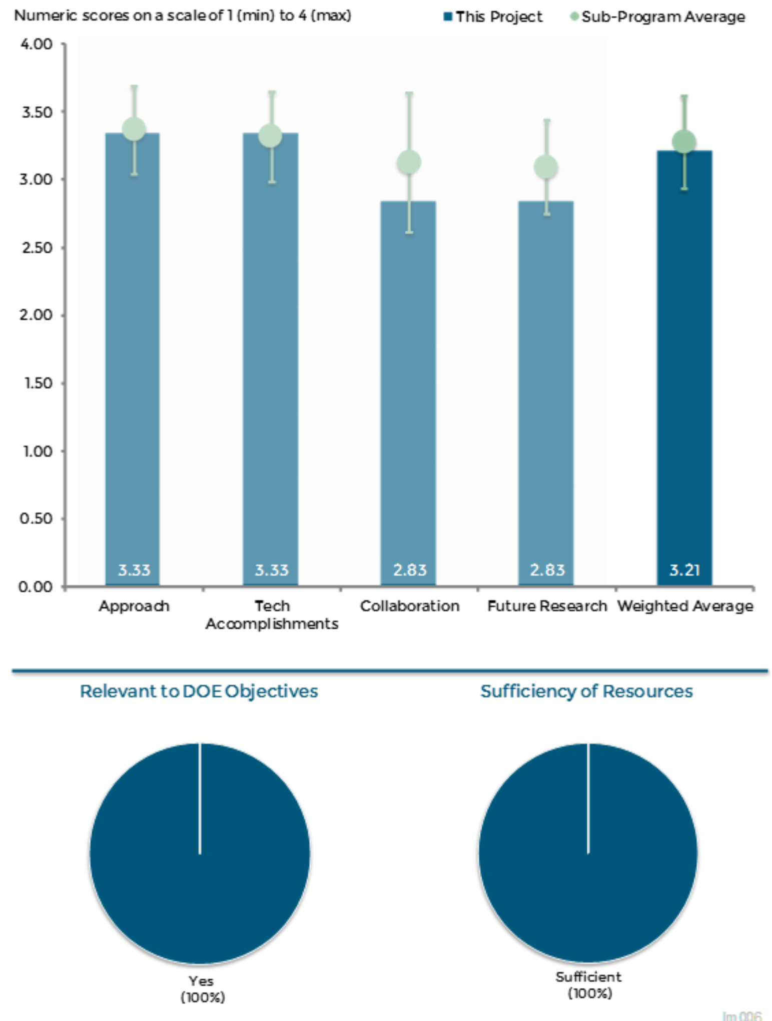


Figure 6-1 Advanced Oxidation and Stabilization of PAN-Based Carbon Precursor Fibers: Felix Paulauskas (Oak Ridge National Laboratory) – Lightweight Materials

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer found that progress is good but noted that actual results are limited by export law and should be provided to reviewers to conduct an accurate assessment.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer said that research appears to be an exclusive activity. The reviewer remarked that the pilot line is open but the technology appears closed.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer said that the plan is to continue, but proposed future research is lacking clear approach to what, when and benefits. The reviewer pointed out that when queried about achieving cost goals, the researcher said never. The reviewer asserted that the researcher must have realistic goals and objectives. The reviewer stated that a positive response to accepting the Funding Opportunity Announcement (FOA) goals and being knowingly aware that the goals are not achievable needs be addressed by DOE. The reviewer added that if the goals are not feasible, the project should not be awarded.

The reviewer strongly recommended that the DOE fund and conduct a life-cycle analysis (LCA) to assess current energy content associated with production, manufacturing and end of life. The reviewer said that DOE will be surprised. Much of the monetary cost of CF is related to energy. Carbon dioxide (CO_2) can be offset by using wind-based energy. The reviewer recommended that end of life (recycling) to redeploy the energy investment must be addressed.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer said that cost is the major enabler to commercial application of CF, the others, which include computer-aided engineering (CAE) and recycling, are not included in the scope of this proposal but significantly influence the probability of commercial application.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer pointed out that the researcher is near end of career, and asked if there is a succession plan in place.

Scale-Up of Magnesium Production by Fully Stabilized Zirconia Electrolysis: Adam Powell (INFINIUM, Inc.) - lm035

Presenter

Steve Derezinski, INFINIUM, Inc.

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer said that this is a very complex project with a number of key tasks and moving parts and the team is working on a new strategy that seems even more promising than the original plan. The reviewer noted that recent work has already generated positive and commercially promising results. Overall, it appeared to this reviewer that the approach is working well and the team seems to be fully capable of addressing the sort of issues that have come and are likely to in the future in a project of this nature. The reviewer concluded well done group.

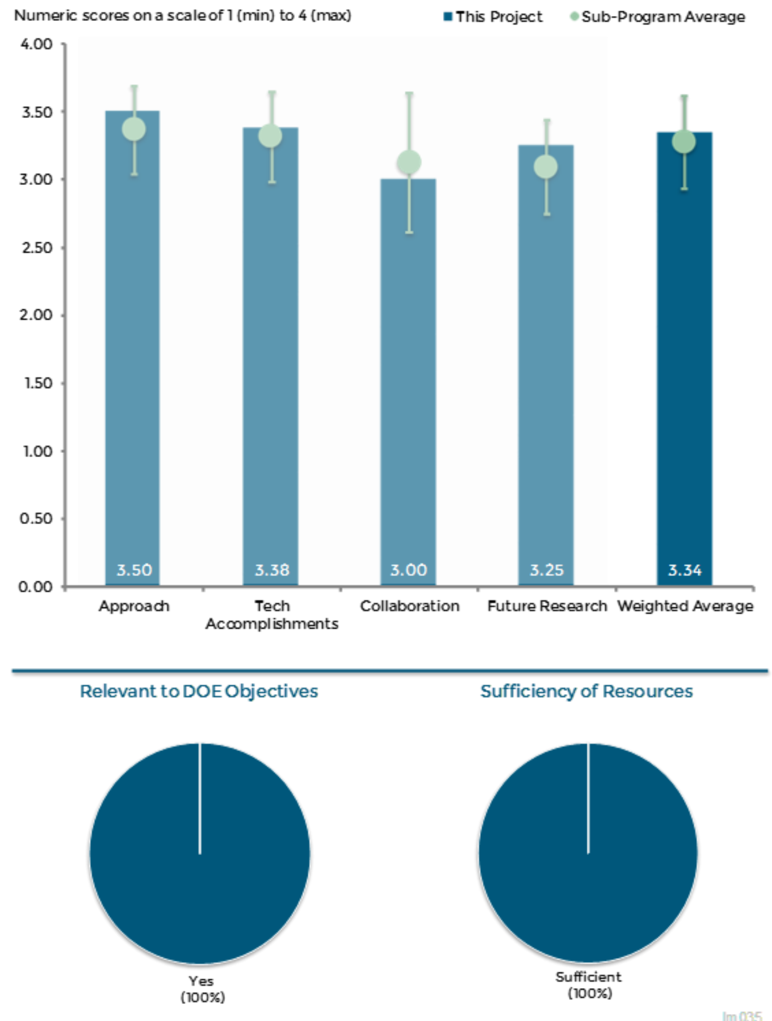


Figure 6-2 Scale-Up of Magnesium Production by Fully Stabilized Zirconia Electrolysis: Adam Powell (INFINIUM, Inc.) – Lightweight Materials

Reviewer 2:

The reviewer said that roadblocks are well defined, and that scale-up issues loom. Regarding magnesium-neodymium (Mg-Nd) alloys (e.g., ZEK100), the reviewer asked how will costs associated with the rare earth (RE) elements be contained. It seemed to this reviewer that much of the customer base wants to move away from Mg-RE alloys because of cost. The reviewer asked why not for Mg-Yttrium (Y), and if there are recycling issues. The reviewer asked if there is any compelling technical reason for Nd. The reviewer said that despite these reservations, the reviewer gave this a 4.0 for the approach that is being developed, and pointed out that this is really challenging work.

Reviewer 3:

The reviewer said that INFINIUM continues to push the envelope in refining Mg using a very novel process. This is essential for starting with a high-purity Mg alloy to which we can alloy in and deliver a higher ductility Mg alloy for automotive applications.

Reviewer 4:

The reviewer noted that the work plan has been altered significantly. The project does not propose to produce primary Mg anymore. The reviewer commented that while it makes sense to produce the expensive master alloys from the market point of view, the change indicates the process may not be not viable for a large-scale Mg production.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer observed progress on all fronts, keep up the great work.

Reviewer 2:

The reviewer said that the technical accomplishments appear to be on-track and of a high caliber.

Reviewer 3:

The reviewer detailed that the project has demonstrated an ability to make very small quantities of material, and has plans to scale up to make greater than 500 lbs. The reviewer asked if the Mg material produced in this project be stampable at room temperature, or if other elevated temperature applications of the as-produced Mg alloys are planned. The reviewer pointed out that the principal investigators (PIs) have a clear understanding of energy balances, system and production costs. The reviewer would like to know what approach to optimizing process parameters will be taken.

The reviewer asked what type of automotive parts are intended to benefit from this technology. If die castings, then it is likely that the impact of this project will be less than what it could be were the focus on closure components or even other structural components.

Reviewer 4:

The reviewer said that the team had shown that it is possible to produce a Mg master alloy containing Nd. However, it will be useful to investigate further whether other RE systems can be produced.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer said that the reach to industry partners is noted and is excellent on all fronts; Spartan, MagPro, and Vehma are all great contacts. The reviewer encouraged the project to press on with the progress and good work.

Reviewer 2:

The reviewer remarked that it would appear that the collaboration among the team members is working well, although the level of detail that was presented as to tasking and budget split-up was rather thin.

Reviewer 3:

The reviewer observed good collaborations with Kingston Process Metallurgy, Boston University, Exothermics, Spartan Light Metals, Vehma, and MagPro. The reviewer asked how the work is being integrated together to address the production and product issues.

Reviewer 4:

The reviewer said that many suppliers are involved. However, the ability to scale-up is not yet proven.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer said that the future directions were presented in reasonable detail and would indicate that a well-developed plan is in place, and the reviewer anticipated good results in future reviews.

Reviewer 2:
The reviewer commented outstanding, very interested in seeing the next steps to scale and make in excess of 650 lbs. The reviewer really liked a previous initiative to partner with companies to scale the process and find a low-cost power source, such as hydro-power. The reviewer asked if the project team has thought about incorporating thermal electrics to capture spent energy and re-use in other processes.

Reviewer 3:
The reviewer noted that future direction was well presented. However, it was not quite clear to this reviewer how the project will produce large enough quantities of material to address needs in the automotive industry, for example. The reviewer asked if the main applications are focused more on engine components/powertrain.

Reviewer 4:
The reviewer pointed out that only a master alloy containing Nd is being investigated. The reviewer remarked that to make this process more viable, other alloy systems need to be investigated, and the possibility of using spent magnets to recover RE elements should be investigated.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer pointed out that Mg is certainly a significant part of the picture for reducing vehicle weight (and consequently reduce fuel consumption) and so this project is definitely aligned with DOE objectives.

Reviewer 2:
The reviewer said that even though it is very long shot, production of Mg-based alloys will enhance the capability of light weighting for auto makers.

Reviewer 3:
The reviewer said that Mg development is always high on the list of automotive lightweighting options and is a major element of VTO's objective, and that the project is well aligned and delivering as promised.

Reviewer 4:
The reviewer said that while Mg continues to face significant room temperature ductility challenges, the present project is aimed at addressing a new approach to making Mg alloys. However, it is unclear if the new Mg alloys that result from this project will be useful for closure components (hoods, decklids, doors, etc.). The reviewer noted that in the end, Mg has only two active basal slip systems and one non-basal system at room temperature. The reviewer asked how this project will overcome fundamental limitations of this hexagonal close packed material.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer commented that no difficulties with the budget were described and so it would appear that the resources available are adequate.

Reviewer 2:
The reviewer said that the current project is appropriately funded, and the reviewer hopes there is another VTO opportunity to expand this type of work with future FOA's on development of high quality, greener and lower-cost Mg and Mg alloys.

Reviewer 3:
The reviewer said that good collaborations have been engaged to support this project. It was not quite clear to this reviewer how it all goes together, however, and some brief discussion about how the various bits of information generated by the different collaborators fit together to support the program deliverables would be helpful.

Mechanistic-Based Ductility Prediction for Complex Magnesium Castings: Xin Sun (Pacific Northwest National Laboratory) - lm057

Presenter

Xin Sun, Pacific Northwest National Laboratory.

Reviewer Sample Size

A total of four reviewers evaluated this project.

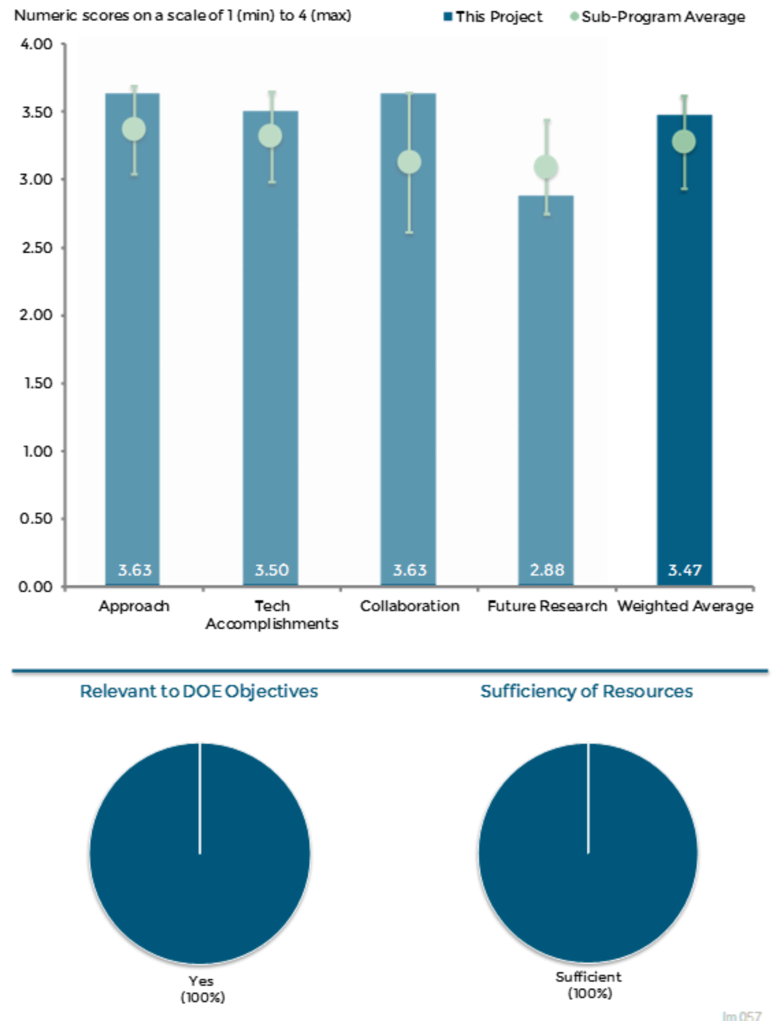


Figure 6-3 Mechanistic-Based Ductility Prediction for Complex Magnesium Castings: Xin Sun (Pacific Northwest National Laboratory) – Lightweight Materials

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer said that the approach is impressive and thorough regarding the generalizability of the results as well as gaining a scientific understanding of variables that influence Mg casting quality. The reviewer said nice job.

Reviewer 2:

The reviewer said excellent work, approach is solid. Modeling the complexity of material processing identifies the significance.

Reviewer 3:

The reviewer said that the approach seems very empirical in nature. The reviewer was unsure of the path to widespread use of the findings on castings of different geometry or composition.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer said that the project is complete and outstanding results were achieved.

Reviewer 2:

The reviewer remarked good progress towards modeling a complex manufacturing/material process.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer said that collaboration was great, and it was good to see original equipment manufacturer- (OEM) involvement at that level.

Reviewer 2:

The reviewer observed very good collaboration.

Reviewer 3:

The reviewer noted that collaboration and cooperation between Pacific Northwest National Laboratory (PNNL) and Ford is apparent.

Reviewer 4:

The reviewer said good collaboration, although the project would gain if all three carmakers were involved.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer said that the project is complete, so no future plans on this project. That said, the reviewer added it would have been good to have a slide on technical transition or barriers to adoption that would have to be overcome, or something similar. The reviewer would have liked a better understanding of the use of the models (as opposed to the approach) to other applications, e.g., military vehicles.

Reviewer 2:

The reviewer said that current research must identify the gaps to conduct future research activities. This type of modeling is in early stages and requires researcher input to go forward.

Reviewer 3:

The reviewer commented that it is not because the project is ending that this kind of work should be stopped. The reviewer opined that it should be extended and generalized to include different Mg alloys, and different casting processes (physical conditions).

Reviewer 4:

The reviewer said that future work is implied (i.e., validate prediction framework), but details are lacking.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer pointed out that accelerating adoption of Mg through the development of analytic tools that predict manufacturing quality will help reduce the weight of automotive structures.

Reviewer 2:

The reviewer remarked that the ability to predict casting ductility (or lack of it) will assist in optimizing component design and thereby minimize weight.

Reviewer 3:

The reviewer said that modeling materials and processes are key to the development of advanced materials and processes.

Reviewer 4:

The reviewer remarked that casting is a fundamental part of the transport industry, and that a better understanding of casting materials can be translated in weight savings.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said that the project is complete.

Reviewer 2:

The reviewer remarked that the project is finished, and guessed that resources were sufficient.

Multi-Material Lightweight Vehicles: Tim Skszek (Vehma) - lm072

Presenter

Tim Skszek, Vehma.

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

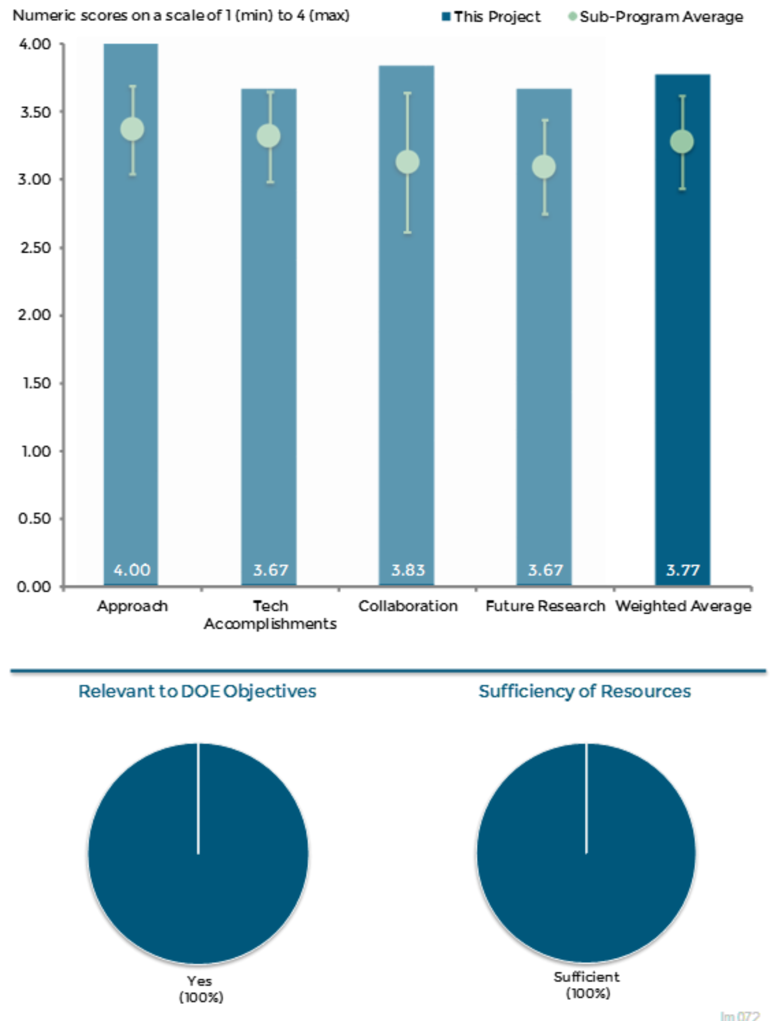


Figure 6-4 Multi-Material Lightweight Vehicles: Tim Skszek (Vehma) – Lightweight Materials

Reviewer 1:

The reviewer said that the approach was excellent to identify state of the engineering art of what is possible regrading multi-material vehicles (MMV), and the reviewer would like to see conclusion slides

Reviewer 2:

The reviewer observed a very good approach, and elaborated that the project is looking at all vehicle systems and reducing the mass wherever possible.

Reviewer 3:

The reviewer identified two approach phases: 24% weight reduction equivalent to a 364 kg weight gain to enabling a smaller engine; and a 50% weight reduction. The reviewer said material optimization is optimizing the best material at the best place, which is very challenging.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer commented that the testing of the Mach I vehicle results is extraordinary, and offered congratulations to the team.

Reviewer 2:

The reviewer emphasized that it is very impressive to have been able to demonstrate so many lightweighting concepts in test worthy vehicles in such a short period of time. However, this reviewer does not feel the project did much to overcome the technical barriers to high-volume production for the industry at large. The reviewer believed the original FOA sought a 50% mass reduction while maintaining the comparator vehicle functionality. The reviewer pointed out that to hit the 50% mass savings even in the hypothetical Mach II much content and functionality had to be eliminated.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer noted that collaboration between Ford and Vehma was clearly strong and effective as well as with all the suppliers.

Reviewer 2:
The reviewer said that collaboration and cooperation between Ford and Vehma is obvious throughout.

Reviewer 3:
The reviewer understands that Ford did not want to share findings of this project with others, but the reviewer thought Ford would have gained if the other two OEMs had been involved.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer commented that the project provides a good list of areas for future research even though the project itself has been completed.

Reviewer 2:
The reviewer noted that the project is ending and the reviewer does not know whether DOE will fund more of this; the reviewer thinks DOE should continue funding but on a broader scale.

Reviewer 3:
The reviewer pointed out that Slide 20 identifies the gaps for the body in white (BIW) and is pretty good (drivers of the gaps would be helpful). The reviewer commented that unfortunately, the vehicle gaps as identified on Slide 25 are a bit vague and general, and mentioned that there were no cost or performance targets. The slide content focused on general technologies (materials, joining, and corrosion) without mentioning specific applications. The reviewer suggested a table of major gaps by specific vehicle subsystem with current performance versus required performance targets.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer remarked outstanding project that demonstrates the state of the art in integrated vehicle lightweighting and current limitations.

Reviewer 2:
The reviewer commented that showing the difficulty in actually producing a commercializable 23.5% lighter vehicle underscores the reality that lightweighting is not easy or inexpensive. According to the reviewer, the project demonstrates technologies in a way that may entice all manufacturers to implement the demonstrated technologies sooner rather than later.

Reviewer 3:
The reviewer pointed out that every time you can eliminate some weight, you use less petroleum.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer noted that the project managed to get to the end, so the reviewer guessed the funding was sufficient, although, for a project of that magnitude, it seemed to this reviewer that it was barely sufficient: more funds would have been better.

Reviewer 2:

The reviewer commented that the project is essentially over.

Reviewer 3:

The reviewer said that while $10 million initially seemed insufficient to do what was required by the FOA, it is not obvious how much additional funding would have contributed to further reduction in the mass demonstrated or in the Mach II design. The reviewer therefore concluded that the funding level was sufficient.

SPR Process Simulation, Analyses, and Development for Magnesium Joints: Elizabeth Stephens (Pacific Northwest National Laboratory) - lm074

Presenter

Elizabeth Stephens, Pacific Northwest National Laboratory.

Reviewer Sample Size

A total of three reviewers evaluated this project.

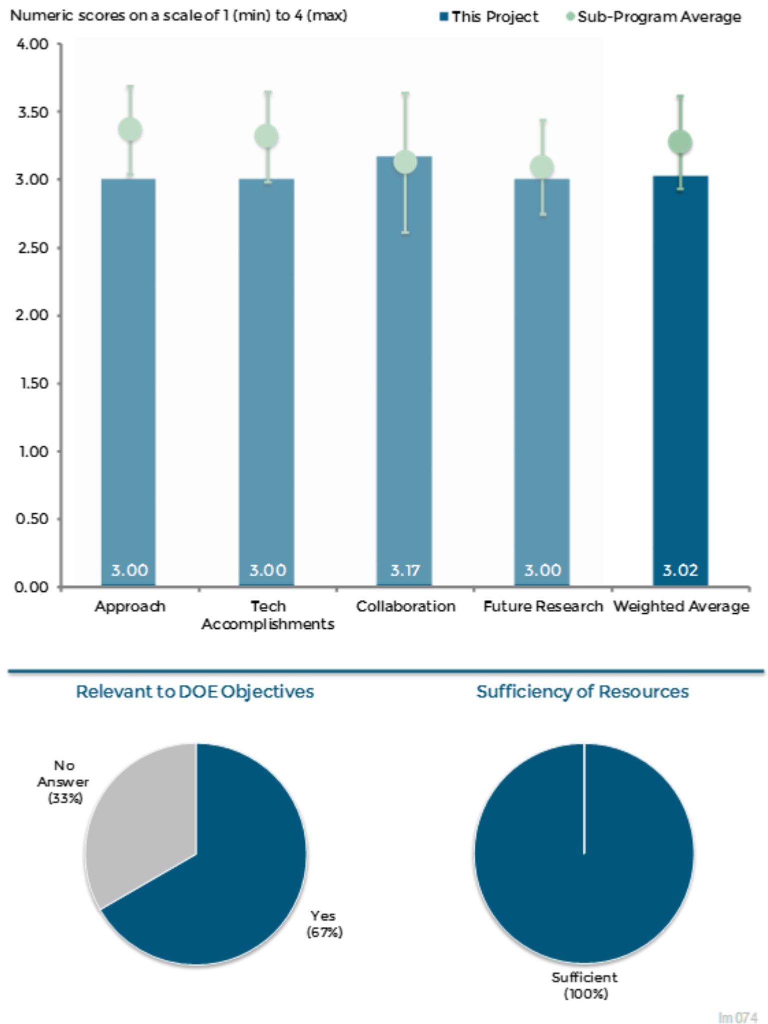


Figure 6-5 SPR Process Simulation, Analyses, and Development for Magnesium Joints: Elizabeth Stephens (Pacific Northwest National Laboratory) – Lightweight Materials

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer observed very solid applied engineering, simulation, and validation work. The reviewer applauded the work, noting that it solved a problem that was of commercial importance to a particular industry/company.

Reviewer 2:

The reviewer believed the work is somewhat off target. For example, focusing on being able to simulate the loads necessary to drive the rivet is of interest but of limited value. The reviewer noted that the ability to simulate the lap shear strength of the rivet joint could be very valuable, but until the accuracy of those simulations can be validated they are of little value. Similarly, testing for fatigue life of the joints is interesting, but according to the reviewer what is really needed is a modeling tool that could accurately predict the fatigue life.

Reviewer 3:

The reviewer commented that in spite of the text on the slides, the reviewer was puzzled as to why rivets are of development importance. The reviewer did not see why rivets are essential other than being a cheap joining method.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer commented outstanding end to a successful project. This is exactly the kind of work that needs to be done: transferring advanced technology into commercial industry.

Reviewer 2:
The reviewer remarked that the work that was accomplished seems to be of little value outside of this project.

Reviewer 3:
Clearly, according to this reviewer, the work was well conducted and the authors delivered what was expected.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer said that partnership with commercial industry was very successful.

Reviewer 2:
The reviewer said that it appeared Stanley has been involved throughout the project but it is unclear as to what Stanley has contributed. The team lacks a supplier that is capable of developing a commercial system that is viable for high volume automotive production.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer said that the project is complete, including the technology transition

Reviewer 2:
The reviewer said that it is good to see that Stanley is generally supportive of the results of this work and in exploring automation of the heating process. The future research areas articulated in the presentation are rather general and difficult to assess, although the general direction appears to be sound.

Reviewer 3:
The reviewer said that the project is almost over and the reviewer hoped there would be no more of this unless it can be unambiguously shown that there is no other way.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer said that successful commercial technology for joining lighter-weight materials such as Mg will benefit the adoption of these materials into automotive applications.

Reviewer 2:
The reviewer said that this could enable joining Mg to other components thereby increasing the use of Mg and reduction of vehicle mass.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer said that the project is complete.

Understanding Protective Film Formation by Magnesium Alloys in Automotive Applications: Mike Brady (Oak Ridge National Laboratory) - lm076

Presenter

Donovan Leonard, Oak Ridge National Laboratory.

Reviewer Sample Size

A total of three reviewers evaluated this project.

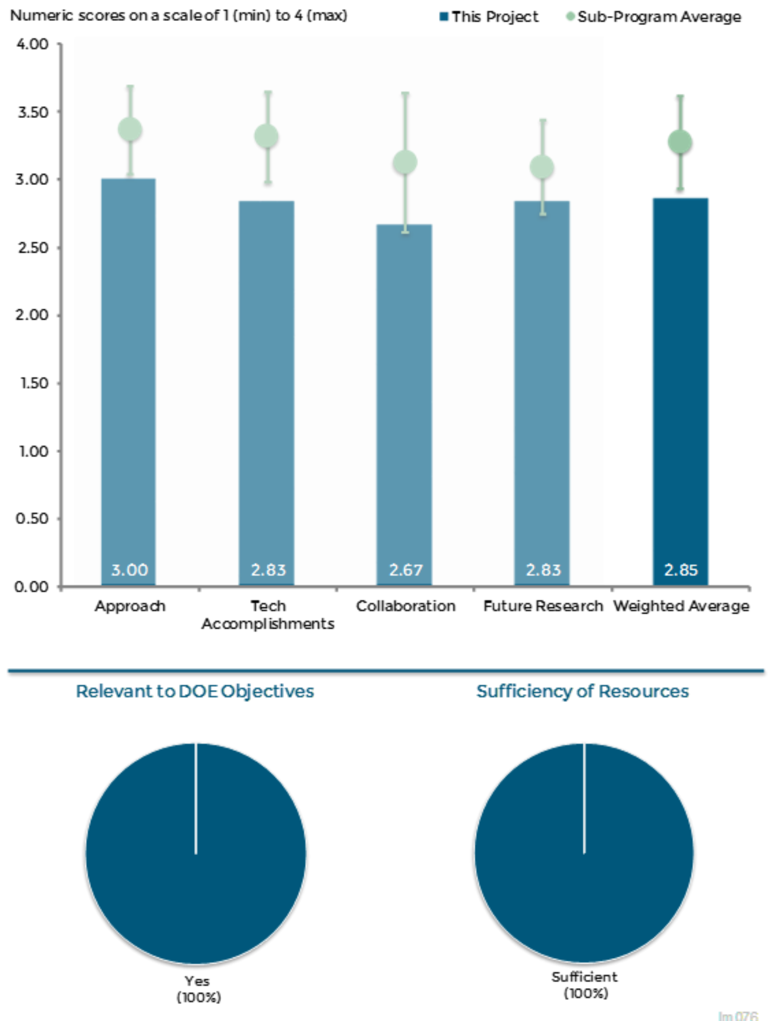


Figure 6-6 Understanding Protective Film Formation by Magnesium Alloys in Automotive Applications: Mike Brady (Oak Ridge National Laboratory) – Lightweight Materials

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer said that understanding Mg corrosion is an important aspect for improving the materials acceptance for structural applications. This project is aimed to develop knowledge about the oxide formation on surface of Mg. The reviewer said that the approach to study bare and coated samples and different alloys is very useful in understanding the interplay of different elements.

Reviewer 2:

The reviewer detailed that the basic science approach to understand the issues surrounding Mg corrosion mitigation coatings is the right approach for this project. The investigators have shown flexibility and creativity in the investigations.

Reviewer 3:

The reviewer noted that the presenter stated (three times in fact) that this study was intended to be a basic science study and was not intended to develop engineering data. In this reviewer’s view, this is the wrong way to approach a study that is part of a program dedicated to reducing the weight of on-road vehicles over the next decade or two. The reviewer commented that in essence, the production of engineering data is not a bad thing and in fact, given the timescale required for new materials introductions into large scale automotive manufacturing, this reviewer perceives that such data is of prime value to the achievement of the DOE objectives.

The reviewer suggested that perhaps this study, which appears to be work of a highly qualified team, would be more suitable as part of a discovery research program such as that conducted as a matter of course by the National Science Foundation (NSF). Perhaps this perception of a lack of weight placed on commercialization is not accurate, but that is the impression conveyed during the talk.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer said that the work certainly appears to be of good or high quality and it would appear that a good deal of basic scientific data has been produced.

Reviewer 2:

The reviewer said that the project continues to make steady progress in understanding film formation on coated and bare Mg. The investigation on two automotive alloys gives direct input to future corrosion mitigation strategies in the automotive industry. The reviewer noted that the investigations of the commercial coatings is interesting but the results are not well integrated into the study. The reviewer suggested that perhaps results should help set direction of the remaining studies.

Reviewer 3:

The reviewer observed that the measurement of hydrogen (H) uptake due to different elements is very interesting. However, effect of elements such as iron (Fe), copper (Cu) and nickel (Ni) on the corrosion of Mg has been very well understood for a long time. The reviewer asked what the relationship is of the current findings to the old knowledge.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer said that the project team has expanded to include key suppliers of coatings and Mg components. The reviewer applauded that these are great additions to the team. The collaboration between the university investigators, the Mg supplier, the coatings company and the automotive Tier 1 parts supplier shows an excellent team and an appreciation for the complexity of solving automotive problems in light weighting.

Reviewer 2:

The reviewer noted that the project is basic research, and it is good to see that many characterization methods are being evaluated to study the surface oxidation. The reviewer noted that Mg is highly unstable and the operational difficulties are well documented.

Reviewer 3:

The reviewer commented that very little was said beyond a simple listing of partners about the tasking or budget split-up or any of the other key aspects of collaboration, and according to the reviewer it is just about impossible to assess how well that aspect of the project is working.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer said that plans to complete the project on time are solid.

Reviewer 2:

The reviewer observed that there seemed to be a good plan going forward, although the presentation was so heavy on scientific data and micrographs, that actual project performance data and forward planning was scant.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer said that Mg is one potential material to achieve significant lightweighting in cars and trucks. The issue of corrosion mitigation is one of the barriers inhibiting the use of Mg components in automotive applications

Reviewer 2:
The reviewer commented that even though it is a very long shot, the basic understanding of the Mg corrosion process can influence development of protection methods. Eventually this will enhance the use of Mg alloys.

Reviewer 3:
The reviewer said yes, it will eventually make an impact, but according to the reviewer the presenter was unable to give any sort of explanation of when or how that might occur.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer pointed out that the cost of the PI at $450,000 per year seems high.

Reviewer 2:
The reviewer emphasized that virtually nothing at all was said about the budget or any of the other project performance data, so this reviewer really cannot comment on resources.

Magnesium-Intensive Front End Sub-Structure Development: Jim Quinn (United States Automotive Materials Partnership) - lm077

Presenter

Jim Quinn, United States Automotive Materials Partnership (USAMP).

Reviewer Sample Size

A total of three reviewers evaluated this project.

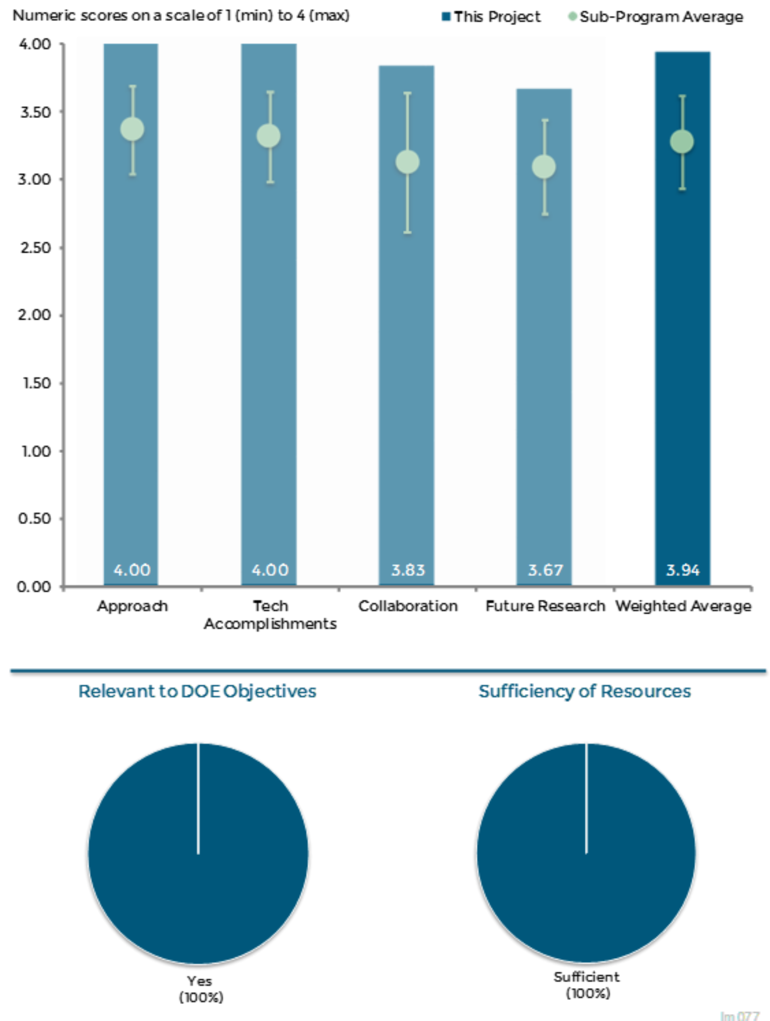


Figure 6-7 Magnesium-Intensive Front End Sub-Structure Development: Jim Quinn (United States Automotive Materials Partnership) – Lightweight Materials

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commented that as noted elsewhere, this is a very complex project that is actually nine separate tasks, and yet, it is has resulted in a tangible progress and so the overall approach must be commended as outstanding.

Reviewer 2:

The reviewer said outstanding approach, 45% weight reduction with respect to steel (which steel), and a 20% weight reduction with respect to aluminum (which aluminum). The reviewer also observed a thorough process, and remarked outstanding international project

Reviewer 3:

The reviewer said complex approach to a technically challenging problem. Not clear from approach how integrated computational material engineering (ICME) is working out and integrating together as a system. The reviewer commented thank you for adding the tasks numbers to Slide Five from last year.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer said that accomplishments are outstanding. Test results are promising and showing areas of success as well as continued challenges. The reviewer noted a lot of good data that should be broadly shared, specifically with TARDEC and Army Research Lab (ARL).

Reviewer 2:
The reviewer said that the work reported upon would appear to be an outstanding contribution to progress toward much lighter vehicle structures. The project is actually nine separate tasks integrated into actual hardware demonstrators of representative automotive structures, so this is an exceedingly complex piece of work involving a very large number of partners and three countries, clearly not an easy task.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer said that the reported collaboration within the project team appears to be very effective, efficient and collegial. The reviewer enthusiastically exclaimed well done on this particular aspect of the work on this complex piece of work.

Reviewer 2:
The reviewer said that collaboration is excellent.

Reviewer 3:
The reviewer pointed out that managing such a large team must have been quite challenging.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer said that the present project is reported to be 90% complete at this point in time (June 2015) and this reviewer takes that view that the future research directions discussed really refer to projects that are yet to be fully defined. Nonetheless, according to this reviewer the remaining tasks appear to be on-track and everything should be wrapped up by the end of calendar year 2015.

Reviewer 2:
The reviewer said that the project is finishing up and the future work slide focused only on the tasks to be performed within this project (which is appropriate). The reviewer would like to see the following in the final report: barriers that still exist within the test structure with respect to the specific design, material, manufacturing and joining techniques. The reviewer would also like a statement as to the applicability or the limitations of the technologies investigated to other vehicle areas. Finally, the reviewer would like a table or other representation of the technologies, problems, application areas (gaps) and performance metrics (current versus required) for Mg.

Reviewer 3:
The reviewer said that the project is over at the end of the year and, regrettably, there appears to be no follow-on.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer said the project is clearly identifying the barriers to adopting a lightweight material such as Mg is supportive of the DOE VTO mission.

Reviewer 2:
The reviewer said that the work of this project is definitely very closely aligned with the DOE objectives because it will lead to much lighter vehicle structures.

Reviewer 3:
The reviewer said that the results speak for themselves.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer noted that it was reported that due some unforeseen difficulties, the project has been extended by six months at no cost to DOE, and at present the resources appear to be adequate to permit completion of the work within the new timeframe (by November 2015).

Reviewer 2:
The reviewer said that the project is nearly over, and the project team has sufficient funds to finish.

Reviewer 3:
The reviewer guessed that resources were sufficient, but in absence of a budget, it is impossible to say for certain.

Aluminum Formability Extension through Superior Blank Processing: Xin Sun (Pacific Northwest National Laboratory) - lm078

Presenter

Xin Sun, Pacific Northwest National Laboratory.

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

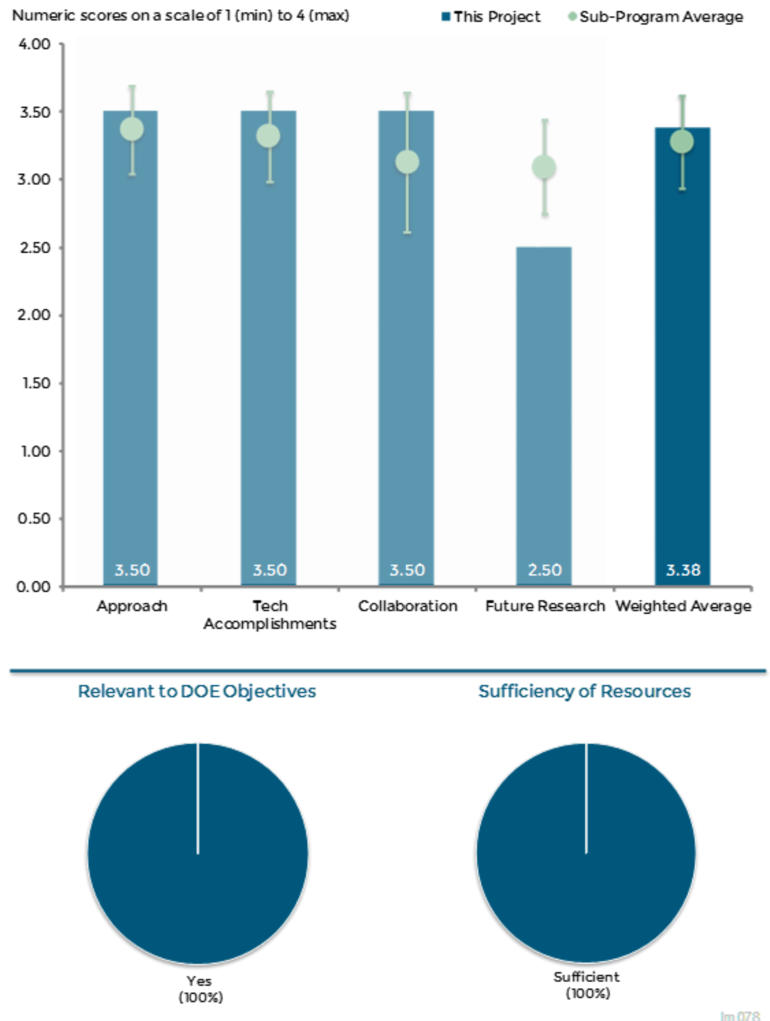


Figure 6-8 Aluminum Formability Extension through Superior Blank Processing: Xin Sun (Pacific Northwest National Laboratory) – Lightweight Materials

Reviewer 1:

The reviewer said end of project, and the approach to the final hole stretching model was straightforward. The reviewer said that overall the project was excellent.

Reviewer 2:

The reviewer observed a good approach in comparing punch clearance to edge cracking.

Reviewer 3:

The reviewer said that room-temperature formability of an aluminum alloy is a significant barrier. Doll tool result for punching is very interesting, even if it is counter-intuitive.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer said outstanding work, yielding unexpected but validated results.

Reviewer 2:

The reviewer said that the test matrix was executed and results were obtained.

Reviewer 3:

The reviewer noted that very significant results were obtained, and the reviewer would have liked to see other thicknesses to test the viability of the scalability.

Reviewer 4:

The reviewer said end of project, the resulting model predicted surprisingly well.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer said that collaboration was limited, focused, well-coordinated, and well executed. The reviewer said that it was difficult to see who else was missing or needed.

Reviewer 2:

The reviewer observed very good collaboration between an OEM, university and a DOE national laboratory.

Reviewer 3:

The reviewer noted that there appeared to be extremely close linkage with the partner organizations, particularly Ford. The reviewer did not give the project a full 4.0 rating only because there are few participants involved, which makes coordination an easier task.

Reviewer 4:

The reviewer would have liked to see a broader collaboration.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer said that future research is in the proposal phase, and focusing on implementation and cost reduction, which is always a good area to focus on after successful research. The reviewer said that how the project team will go about doing it will make all the difference. The reviewer would prefer to see some statement as to the extent the basic work should be expanded (e.g., other alloys, etc.).

Reviewer 2:

The reviewer pointed out that there is no application demonstration planned.

Reviewer 3:

The reviewer noted that the project is ending, and asked should that kind of work be extended.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer said that anything that increases the application of aluminum in place of conventional steel will greatly assist in vehicle lightweighting efforts.

Reviewer 2:

The reviewer said that understanding material processing parameters to enable application and acceptance of lightweight material is one key to commercial use and application of lightweight materials.

Reviewer 3:

The reviewer detailed that improving performance of forming processes for lightweight materials lowers the barrier for adoption. Developing a fundamental understanding of the process and having a simulation model available will allow companies to optimize their processes for their products. The reviewer said that anything to lower the adoption of new lighter-weight materials into vehicles will help make lighter weight vehicle commercially successful.

Reviewer 4:

The reviewer said yes, in the sense that the manufacturing would be quicker (and therefore cheaper).

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said that the project is complete and successful.

Enhanced Room-Temperature Formability in High-Strength Aluminum Alloys through Pulse-Pressure Forming: Rich Davies (Pacific Northwest National Laboratory) - lm079

Presenter

Rich Davies, Pacific Northwest National Laboratory.

Reviewer Sample Size

A total of three reviewers evaluated this project.

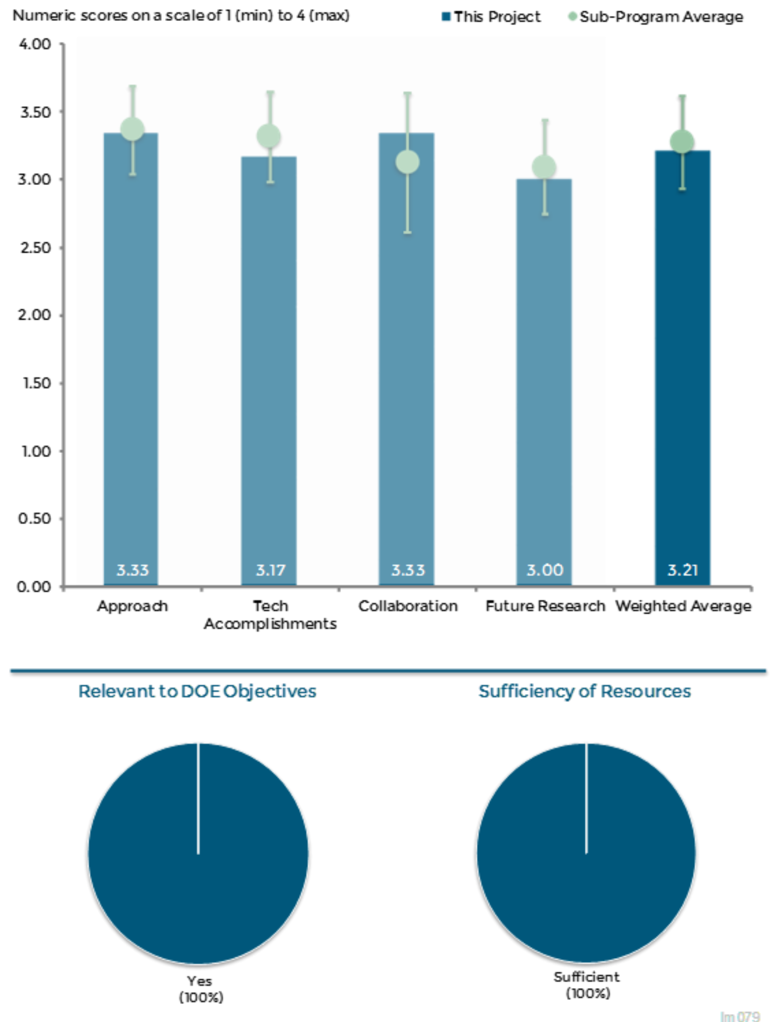


Figure 6-9 Enhanced Room-Temperature Formability in High-Strength Aluminum Alloys through Pulse-Pressure Forming: Rich Davies (Pacific Northwest National Laboratory) – Lightweight Materials

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer said that the project is well designed, and is focused on a novel forming process aimed at forming 7xxx alloys at lower temperatures (room temperature is preferable). The reviewer commented excellent use of government-funded hardware (high-speed cameras).

Reviewer 2:

The reviewer said that the approach to address the formability of 6xxx and 7xxx aluminum sheet with both national laboratory-level science and automotive supplier, American Trim and Magna, production minded partners is great. The reviewer said that performing the experiments at PNNL and then investigating commercialization with a supplier is a strong approach to the challenges.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer said that there has been solid progress on the technical areas for this project. Good information on the strain rates during pulse pressure forming. The reviewer said that the decision to only simulate an automotive part is understandable but disappointing.

Reviewer 2:

The reviewer noted that while the project did not succeed in forming a 7xxx part, the learnings derived will be invaluable for future projects aimed at developing methods for producing 7xxx automotive parts at room temperature. The reviewer had one note to help the principal investigators: all graphics need to contain relevant quantitative data. For example, on Slide 4, the forming limit plot has the labels possible high rate and quasit-static. Please quantify all such terms. The reviewer asked if there was a finite element simulation aimed at predicting whether or not a 7xxx part could be formed. The reviewer would like to know why the part making not succeed.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer said that five partners have been engaged to work on this project with PNNL. The engagement of each appears to have been sufficient enough to help the PIs achieve program deliverables.

Reviewer 2:

The reviewer said great teamwork across the full spectrum of the organizations and automotive supply chain.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer remarked end of the project; no suggestion for future direction

Reviewer 2:

The reviewer pointed out that the project will likely finish on time.

Reviewer 3:

The reviewer said that it appeared that a main barrier to the wider-scale implementation of the pulse-pressure forming method is supply chain. The reviewer asked if the PIs have investigated the reasons why, and if this is related to the fact that 7xxx are primarily aircraft alloys. The reviewer asked where are (is) the weak links (link) in the supply chain. The reviewer concluded that a more thorough investigation is required.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer said that aluminum 7xxx promises greater vehicle lightweighting if in fact the material can be stamped into body structure components (b-pillars, roof rails, rockers, hinge pillars, a-pillars, one bars, etc.).

Reviewer 2:

The reviewer said that high-strength aluminum is a key material for lightweighting. The forming of high-strength aluminum is one of the challenges facing the material.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented that resources are sufficient.

Integrated Computational Materials Engineering Approach to Development of Lightweight 3GAHSS Vehicle Assembly: Lou Hector (United States Automotive Materials Partnership) - lm080

Presenter

Lou Hector, USAMP.

Reviewer Sample Size

A total of four reviewers evaluated this project.

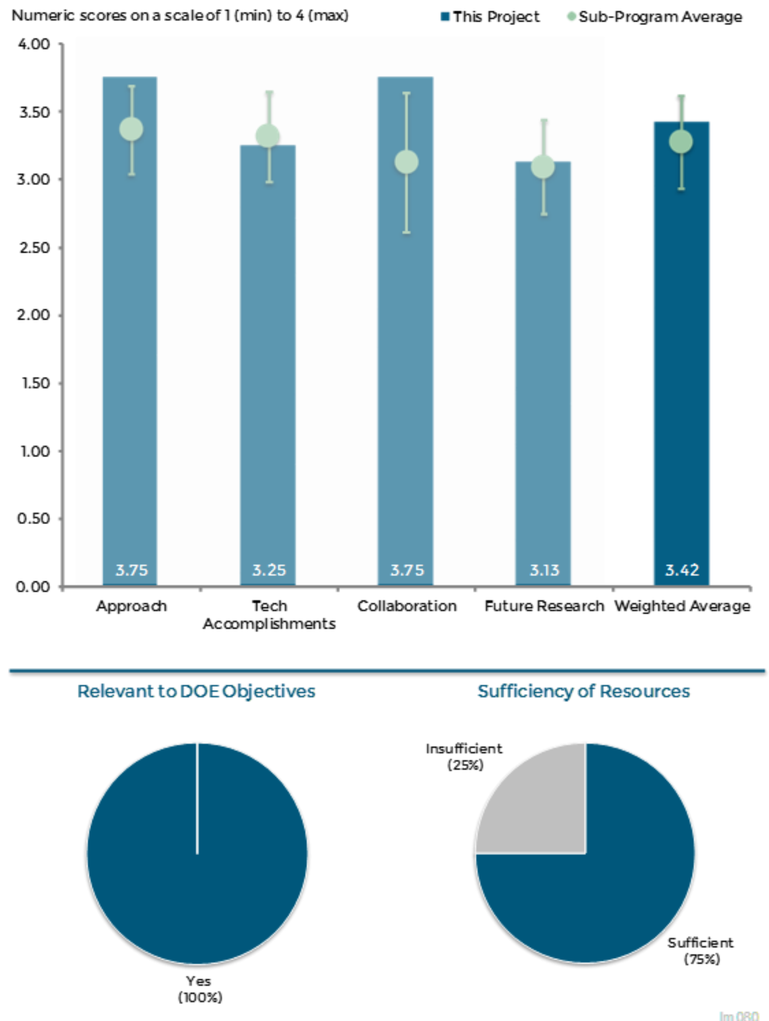


Figure 6-10 Integrated Computational Materials Engineering Approach to Development of Lightweight 3GAHSS Vehicle Assembly: Lou Hector (United States Automotive Materials Partnership) – Lightweight Materials

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer said that this is a very complex project involving a substantial amount of new knowledge and novel experimental technique development. As such, there are a lot of moving parts and the team is encountering significant challenges, some of which are unforeseen and unforeseeable. The reviewer said that the team appears to be working very hard and staking a systematic approach to the planned tasks and to the solution of the problems that are coming up and they are succeeding. The reviewer concluded overall, this is an excellent piece of research & development and a talented and well-integrated team is doing a fine job on it.

Reviewer 2:

The reviewer stated that this project is one of the most ambitious and important projects currently being pursued to determine the utility and efficacy of ICME. It is important because it is using the ICME framework of linking different length scale simulation models (atomistic material though macro product performance) to not only accelerate the adoption of materials (as has traditionally been done), but rather to extract the required material properties from the performance requirements to create new materials; a materials by design approach. The reviewer said that generating and validating the models based on an existing material that is near the desired properties is a good approach. According to the reviewer, but it is still technically difficult and of concern how generalizable the various models are to the new material domain.

The reviewer suggested that the project team please create a slide next time that describes the limitations of the models (chemistry limited, scale limited, thickness limited, process limited, etc.). The reviewer noted that it was mentioned that dislocation models would be necessary, but more generally, putting together a slide that shows the types of factors that have to be experimentally measured each time to validate models or the expected factors that would limit the generalizability of the model.

Reviewer 3:

The reviewer said that the experimental approach and the theoretical work are excellent. The reviewer said that the goal is impressive, but the proposed operation schedule appears to be too optimistic.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer reiterated that there have been significant challenges and they are being overcome as they come up.

Reviewer 2:

The reviewer said that two steel compositions have been identified; even though this is due to the efforts of Colorado School of Mines and steel makers, accepting these as the base alloys is commendable.

Reviewer 3:

The reviewer asked why nothing was reported on the completed cost model. The reviewer wondered are any of the cost factors related to the material models (e.g., chemical composition). In the future this reviewer would like to see the milestone table accomplishments against the milestones for the whole project to judge progress. The reviewer said that a lot of work and progress appears to have been performed on a very complex project.

Reviewer 4:

The reviewer is not yet positive as to whether the team can deliver in the project timeframe, and asked about validation. The reviewer pointed out that austenitic transformation is not yet included in the modeling, coupon size only at the preliminary stage and heat treatment samples are even smaller, and the team will need ingots of about 800-1,000 kg before the team can see the end of the tunnel. The reviewer said that it appears ICME will be a function of size and weight

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer said that collaboration is outstanding given the number and variety of organizations involved. As expected on a project that involves this level of technical complexity and integration, specialty cross functional task teams have been created

Reviewer 2:

The reviewer said that the work of this large and complex team looks to be extremely well integrated and collaborative.

Reviewer 3:

The reviewer said good team, and noted extensive collaboration.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer noted there are some tough challenges, but looks good.

Reviewer 2:
The reviewer recommended that the team has to concentrate on obtaining larger ingots.

Reviewer 3:
The reviewer said that it is difficult to assess future work plans without milestone chart and better explanation of where the pieces are going, when specific system level tests or demonstrations are going to be conducted. The reviewer said that the lack of these integrated milestones is part of why risk assessment is relatively weak. For example, a risk that is not addressed is what happens if a major university PI becomes unavailable to the project. The reviewer wondered if this is not an issue. The reviewer inquired if there are sufficient grad students/colleagues who can pick up the work without delay.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The target of 35% weight reduction makes sense and it certainly aligned with DOE's goal.

Reviewer 2:
The reviewer said that this is an important project for demonstrating how new lightweight materials could be developed using ICME. ICME to date has primarily been used to accelerate adoption of materials into application based on optimizing forming and assembly parameters. The reviewer stated that this project aims to use the process to optimize material parameters.

Reviewer 3:
The reviewer pointed out that stronger material implies less material, resulting in a lighter structure.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
To this reviewer, the funding is clearly insufficient: larger intermediate ingot sizes are pricy and the magnitude of the testing increases with ingot size; there is no way that intermediate sizes can be avoided before obtaining industrial size ingots with the desired physical characteristics. The reviewer stated that DOE should already plan on extending the length of the project. The reviewer recommended that makers of large industrial ingots of specialty materials should be approached and included in such project.

Reviewer 2:
The reviewer said that resources look fine.

Reviewer 3:
The reviewer said that the impact of this project justifies the number of participants and the associated cost. At this time, there appears to be sufficient funding, but the reviewer expressed some concern that later manufacturing costs will be higher and affect the project. This is particularly true if there are any delays/unexpected barriers that require an extension.

GATE Center of Excellence at UAB for Lightweight Materials and Manufacturing for Automotive, Truck and Mass Transit: Uday Vaidya (University of Alabama, Birmingham) - lm081

Presenter

Uday Vaidya, University of Alabama, Birmingham.

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

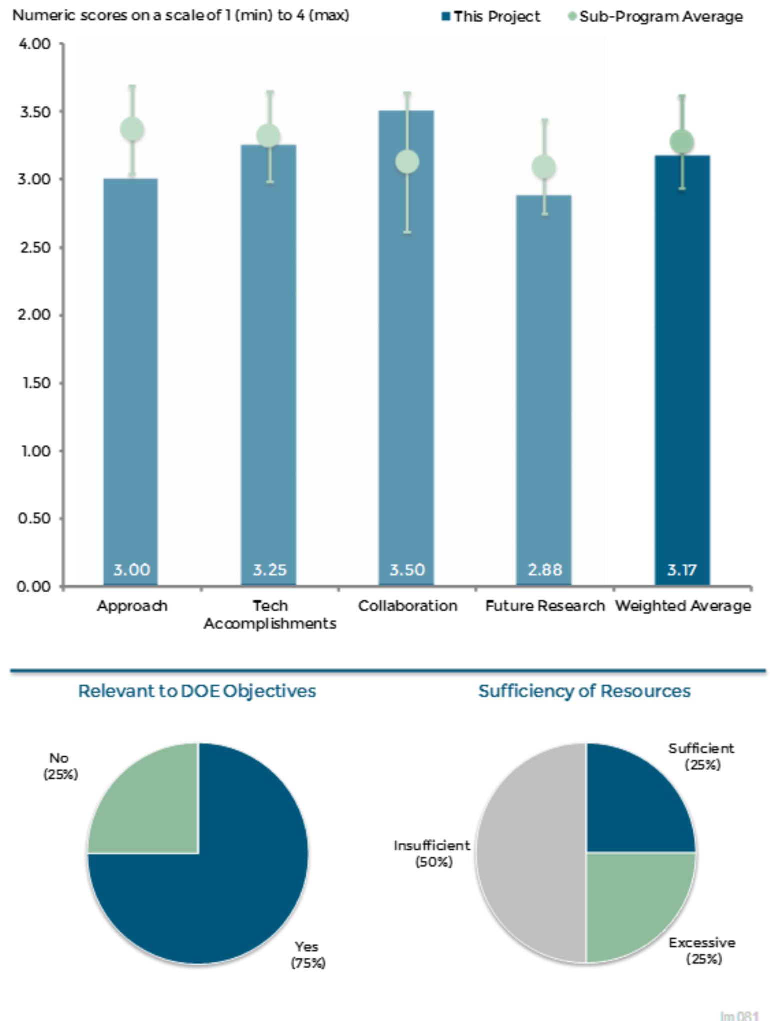


Figure 6-11 GATE Center of Excellence at UAB for Lightweight Materials and Manufacturing for Automotive, Truck and Mass Transit: Uday Vaidya (University of Alabama, Birmingham) – Lightweight Materials

Reviewer 1:

The reviewer thinks that GATE is an outstanding formation program and that model of instruction should be exported to other fields of manufacturing.

Reviewer 2:

The reviewer said that it appears the program is effective in educating students in the area of automotive lightweighting materials.

Reviewer 3:

The reviewer described that the rating is a reflection of the presentation and its structure, more than the value of the work. The reviewer is a strong supporter of the effort and believe it is worthy of a 4, but the presentation does not show this. The reviewer thinks that based on the Q&A, this program has been outstandingly managed and the funding has been utilized far better than the presentation suggests. For example, the leveraging of funding and rotation of the students is significant and worthwhile. The reviewer recommended that a slide should show this. This review is very difficult when all the information is in aggregate and not presented as progress since last year. Also, the research projects are presented as disjoint projects. There do not appear to be overriding themes. The reviewer said that this was a problem last year as well. Slide 6 attempts to present a structure, but it is not used at all in the presentation. The reviewer detailed that there are a finite number of students who are presumably working on a series of experiments/projects that lead to new knowledge. While that would be one way to structure the presentation, it is not used. The reviewer acknowledged that the Graduate Automotive Technology Education (GATE) program is undoubtedly very good and useful, but the annual review slides are not helpful in communicating annual progress or future plans.

Reviewer 4:

The reviewer said that the approach appears scattered rather than focused. The reviewer asked what are any documented successes from the center that have been produced in lightweight composites, and what weight savings in automotive components have been produced based on the GATE projects.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer said that the project has trained many students, and held workshops on lightweight metal casting, composites manufacturing, materials selection and recycling. The reviewer said that it is difficult to assess the technical merits of what the workshops accomplished. However, the results of the student efforts appear to be substantial in number and quality. The reviewer concluded that it appears that the program largely accomplished its mission and objectives for the year.

Reviewer 2:

The reviewer said that the accomplishment on supporting a handful of students is acknowledged but there is no indication of advancing the state of the art. The reviewer asked what the advancements are that have been born at GATE.

Reviewer 3:

The reviewer said no change in the education course developed from 2014 to 2015 according to the slides, but the speaker claimed that two courses were new. The reviewer requested please make this clearer. The speaker talks in terms of course development since inception, which was four years ago. The reviewer would also like to have graphs of student attraction, retention, and graduation over time by year, and not in total. The reviewer was unclear about how the research projects are developed and selected or transitioned. There are a variety of research projects integrated with an educational program in automotive lightweighting, and for the reviewer it was difficult to assess how the research projects fit together, if at all.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer said that there are indications of regular and strong interactions with several industrial and educational organizations.

Reviewer 2:

The reviewer said that the University of Alabama is at the center of a large pool of carmakers: they are in a unique position.

Reviewer 3:

The reviewer gave kudos to the team for engaging both community colleges, Oak Ridge National Laboratory (ORNL), and industry. The reviewer was happy to see that this year's presentation more clearly presented where the students are going and what they are doing. The reviewer offered congratulations. The reviewer suggested perhaps putting in a table information such as percentage of students in the program working in other organizations, hired, interning, or other interactions. The reviewer suggested presenting a slide tracking graduates, or plans to do so. The reviewer inquired if the first graduate was in 2013. If not, that graduate should be surveyed in 2015 (three years later).

Reviewer 4:

The reviewer commented fair; there is little evidence of the purported collaborations. This reviewer had hoped to see examples of projects with industrial partners in which the contribution of the center was clear.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer said the plan to the end of the project is good and should be continued.

Reviewer 2:
The reviewer would like to see more how the future plans fit together over time in fiscal years 2013, 2014, and 2015. The reviewer would like to see ideas on program sustainment past DOE funding. There must be some rationale to the projects that are pursued, even if the funding sources are mixed. The reviewer suggested showing a matrix of projects over time with percent of funding source (if mixed/ necessary) by year grouped by theme or overarching strategic goal.

Reviewer 3:
The reviewer said that the description of future work appears to be too general.

Reviewer 4:
The reviewer said that proposed future research is poor, the center appears to be hoping for more industrial projects.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer said yes, and detailed that increasing the number of engineers capable of designing and manufacturing automotive systems with new lightweight materials contributes to the commercial adoption of these materials the DOE goal of lightening vehicles to decrease petroleum use.

Reviewer 2:
The reviewer said that teaching our future engineers and researchers how to manufacture and work with these lightweighting materials is crucial for rapid and widespread application of the materials in vehicle lightweighting.

Reviewer 3:
The reviewer said yes, because the students learn how to use light materials

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer was actually impressed with the amount of research being conducted and the number of students being supported for the amount of funding. The reviewer concluded very good investment. Additional funding would presumably increase student participation and grow the program. The reviewer is concerned that without a plan for future sustainment without VTO funding, the investment may be lost. The reviewer recommends a one-year extension with funding to ensure the future long term success of the program (if necessary).

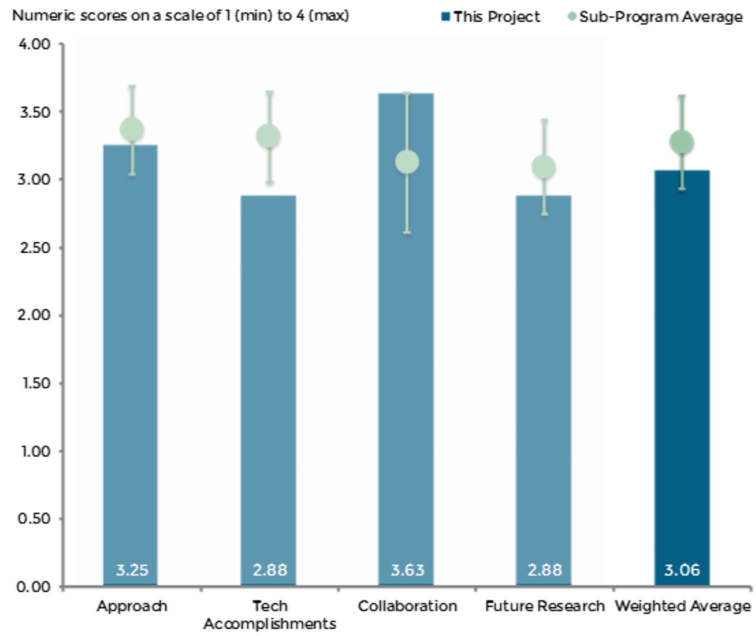
Reviewer 2:
The reviewer said that resources appear sufficient for current level of activity. However, it would appear appropriate and desirable to increase funding to be able to expand the program further.

Reviewer 3:
The reviewer qualified the response given about resources by stating but they could do more with more funding and that would be for the benefit of the entire country.

Reviewer 4:

The reviewer questioned the return on investment for this program.

Validation of Material Models for Automotive Carbon Fiber Composite Structures: Libby Berger (General Motors) - lm084



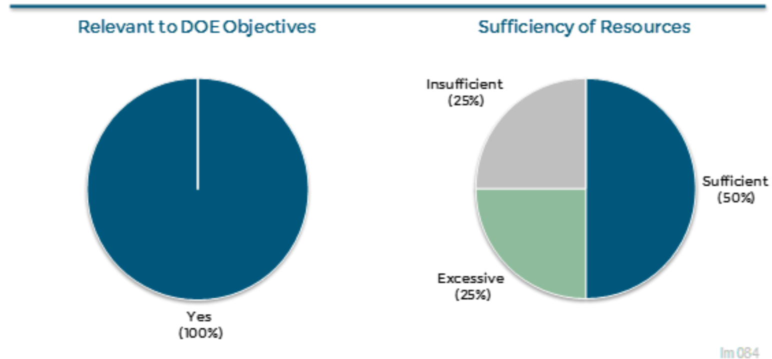


Figure 6-12 Validation of Material Models for Automotive Carbon Fiber Composite Structures: Libby Berger (General Motors) – Lightweight Materials

Presenter

Omar Faruque, Ford.

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer observed good comparison between steel front bumper and crush can (FBCC) and composite FBCC.

Reviewer 2:

The reviewer said that the project objectives are focused on engineering, analysis, manufacturing and component-level validation testing a functional automotive component.

Reviewer 3:

The reviewer said that establishing the steel benchmark was an outstanding method for controlling geometry effects and determining the acceptable simulation validation range. The reviewer recommended a slide that more clearly shows the thought process behind the validation tasks, i.e., steel design to determine validation limits, competing models, limitations of the competing models, etc. The slide could also present how the project will identify gaps in carbon fiber composite (CFC) modeling. The reviewer would also like to see a statement that more clearly addresses the expected limitations of the models. Are the models highly geometry dependent, load sensitive, material limited, etc. The reviewer asked what the anticipated applicability is of the models only for the structure shown, similar bumper structures of the same materials, other structures that have certain characteristics, and what are these characteristics.

Reviewer 4:

The reviewer said that the approach to performing the work is too broad and does not describe integration of key activities that are needed for the successful outcome of the project. There also needs to be additional thoughts given to the details of CAE correlation plan, and the key factors that can contribute to successful correlation activities. The reviewer observed that very little content was shown on the development techniques used for composite bumper beam design and assumptions that were made to derive the details of the concept design.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer said that the project is significant and well thought out. Milestones are logical and one can see how they build on each other. The reviewer noted an acknowledgement of a slow project start, but apparently no impact on schedule.

Reviewer 2:

The reviewer detailed that much of the presentation material covered the approach versus showing key outputs from the conducted studies. No reference was made towards to details of characterization techniques used to generate the needed parameters for CAE material inputs. The reviewer said that if coupon level experimental data has been generated, then there was an opportunity to identify the gaps of the existing commercial codes and university developed modules against coupon level experimental data while waiting for the testing of fully assembled bumper beam components.

Reviewer 3:

The reviewer listed the following: correlate physical properties; compression molding for fabrication; establish reliability gap because strength for composite FBCC seems to be an issue; and corrosion between CF bumper and frame was not considered at this time, but should be done.

Reviewer 4:

The reviewer said that the 2015 progress report versus 2014 report lacks significant progress.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer commented large pool, and good members.

Reviewer 2:

The reviewer acknowledged an outstanding collaboration slide. Each subcontractor has a clear task in the project. The reviewer was still unclear how the meso-scale and micro-plane representative unit cell models are integrated/work together when they are developed by two different teams.

Reviewer 3:

The reviewer concluded that coordination with different partners appears reasonable. The reviewer said that contributions from ESI are not very clear. Coordinating CAE model development and testing with University of Michigan and Northwestern are not clear. The reviewer said that possible integration of university-developed codes with commercial software were not reflected. The reviewer said that coordination with validation of material models was not reflected in the plan.

Reviewer 4:

The reviewer said that although the number of participants and degree of collaboration is very good, it may also be the source of the lack of progress.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer said that the project is in good hands. Final results may be limited by the present funding.

Reviewer 2:

The reviewer said that future plans are logical, low-risk, and effective at achieving project goals. The reviewer suggested that thought should be given to more systematically formulating the robustness of the models, specifically, their sensitivity to changes in system factors (e.g., materials, geometry, energy, and dynamics speed). For example, the reviewer asked about the likeliness of any model to be able to extrapolate to military-like high strain rate events.

Reviewer 3:

The reviewer explained that because not much result was shown on CAE correlation activities at a coupon or component level, it is unclear whether the project team has a plan in place to address the critical issues that the team may run up against in the full bumper beam assembly.

Reviewer 4:

The reviewer said that future research is not articulated in the 2015 AMR report. The significance of this project is to correlate predictive material models to actual test results. The research plan does not articulate a plan to deliver the Project Objectives. The reviewer said that there was no discussion regarding non-destructive testing.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer commented that vehicle lightweighting is one of the key technologies for improving vehicle fuel efficiency. Understanding how composite structures behave in high-strain rate events and being able to model that behavior is a requirement to ensure commercial adoption of this lightweight material.

Reviewer 2:

The reviewer indicated that an assessment will identify the gaps in predictive capability.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said that the team has sufficient funding for the composite structure build and test.

Reviewer 2:

The reviewer observed sufficient resources, and recommended better emphasis on the efficient planning of key activities towards key objectives of the program.

Reviewer 3:

The reviewer believed that the project is too skimpy on testing.

Collision Welding of Dissimilar Materials by Vaporizing Foil Actuator: Glenn Daehn (Ohio State University) - lm086

Presenter

Glenn Daehn, Ohio State University.

Reviewer Sample Size

A total of three reviewers evaluated this project.

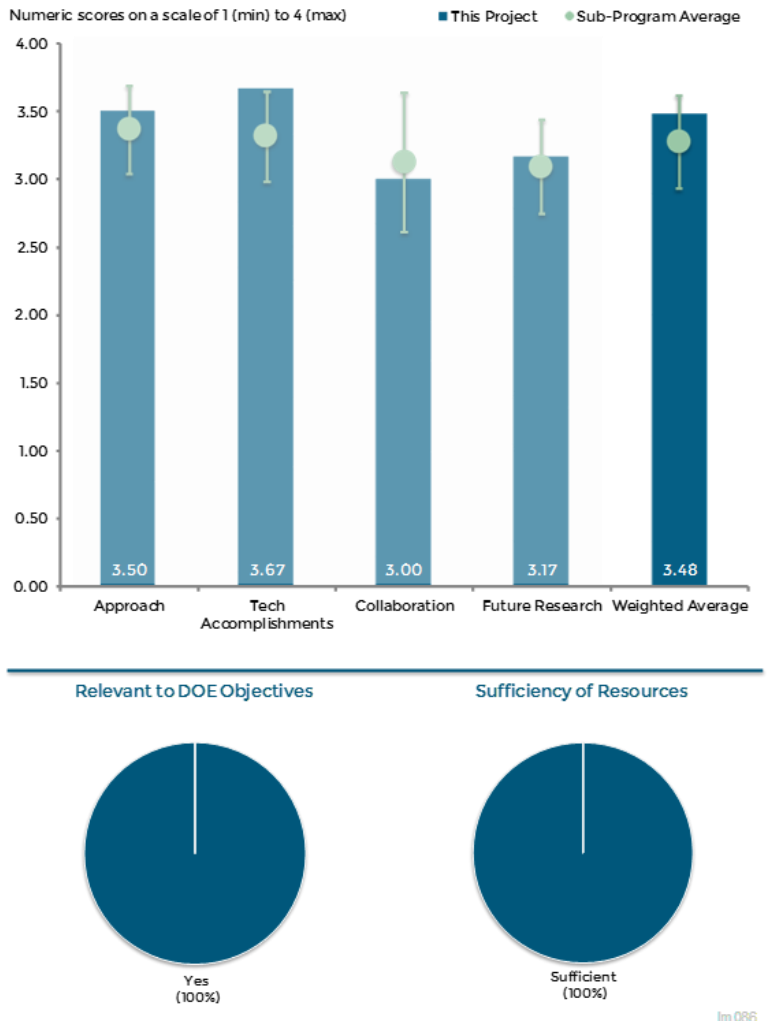


Figure 6-13 Collision Welding of Dissimilar Materials by Vaporizing Foil Actuator: Glenn Daehn (Ohio State University) – Lightweight Materials

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer observed an interesting and very thorough approach to determine what influences the process and to quantify its influence on strength and corrosion.

Reviewer 2:

The reviewer commented innovative project that can have great outcomes for the car industry and others. Vaporizing foil actuator welding is a technology with great promise. The reviewer also said joining dissimilar material.

Reviewer 3:

The reviewer found that the approach is solid, with a screening study of 15 mixed material combinations and then a focused study on six combinations. The reviewer said that it is okay to focus just on flat welding

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer said that the PI provided information showing excellent progress.

Reviewer 2:

The reviewer noted that collision weld is material transfer into each other, and that corrosion testing in progress. The reviewer pointed out that peel strength in joint is greater than in material, and appears to be a very robust process.

Reviewer 3:
The reviewer said that the progress is good, but the rate of progress is a bit in question given the few months remaining before the end of the project. The corrosion testing will further inform the future value of this method. The reviewer said that the need for a standoff gap appears to be problematic in automotive design. The reviewer suggested please look more at the fixturing and with the urethane washers to create the standoff. The reviewer said that these would be difficult to include in high-volume processing.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer said that it appears collaborators have primarily provided opinions and guidance, rather than shared responsibility for the research. Therefore, not much coordination was evident (or needed).

Reviewer 2:
The reviewer said that there was little interaction with a supplier to commercialize this process, and hopefully Johnson Control will help in the next years.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer said solid plan to wrap up the project.

Reviewer 2:
The reviewer said that it is hard to ascertain what will be done in this project as opposed to what someone should do.

Reviewer 3:
The reviewer said that the project is close to the end, and asked if DOE intends to pursue such work.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer said that enabling material replacement with a lighter one makes a lot of sense.

Reviewer 2:
The reviewer said that mixed material joining is a key enabler for many lightweight vehicle scenarios.

Reviewer 3:
The reviewer said that this provides a new approach to join dissimilar lightweighting materials for vehicles.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

There were no reviewer comments on resources.

Active, Tailorable Adhesives for Dissimilar Material Bonding, Repair and Assembly: Mahmood Haq (Michigan State University) – lm087

Presenter

Mahmood Haq, Michigan State University.

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

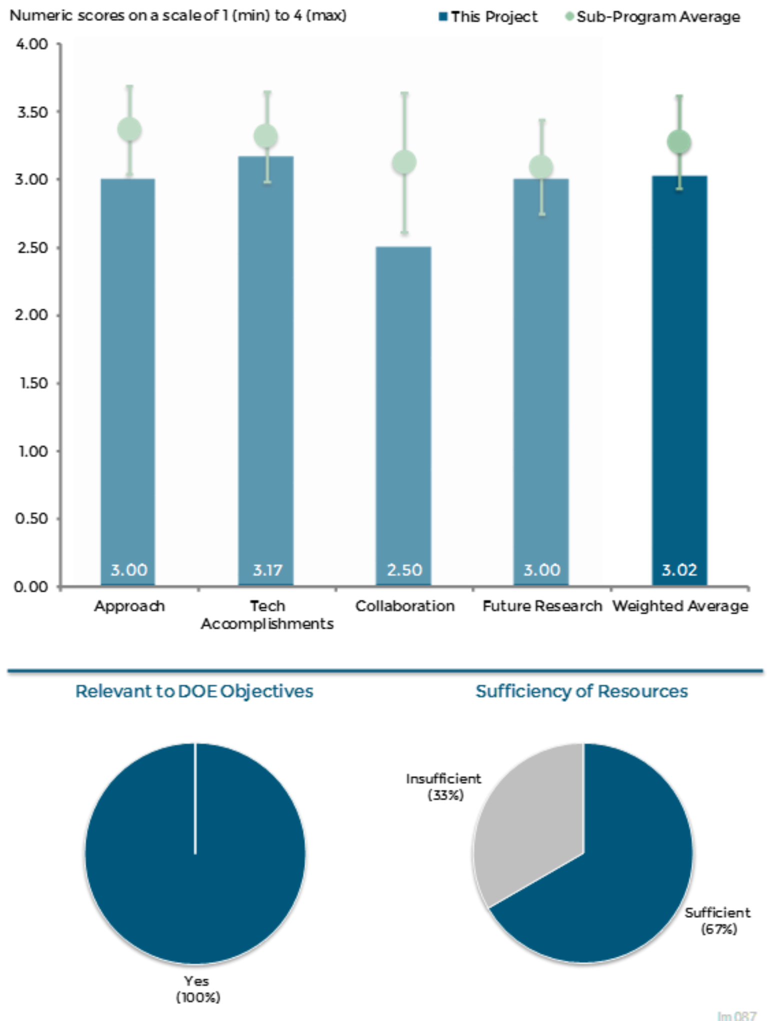


Figure 6-14 Active, Tailorable Adhesives for Dissimilar Material Bonding, Repair and Assembly: Mahmood Haq (Michigan State University) – Lightweight Materials

Reviewer 1:

The reviewer commented excellent use of graphene in the approach and praised the mechanism for assembly and de-assembly as excellent and timely.

Reviewer 2:

The reviewer expressed that this is a very good approach to an interesting technical concept.

Reviewer 3:

The reviewer judged that the approach as not clearly appropriate for this study and questioned exactly how the investigators will use a rational computational materials approach to advance this study. The reviewer observed that no evidence is given in this presentation, and said that there is an apparent random walk rather than a directed approach.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer praised the progress from year one to year two as remarkable, citing the successful assembly and de-assembly as a great feature of this project.

Reviewer 2:

The reviewer applauded solid, valuable accomplishments and acknowledged the active sites identified in the adhesive chemistries as a valuable addition to the state of the art. The reviewer offered that improvements in the lap-shear strength by 3% to 5% graphene nanoplatelets (GnP) to nylon is a good accomplishment.

Reviewer 3:

The reviewer cited good results but offered it would be better to use an adhesive other than nylon, because the auto industry makes only limited use of nylon due to its affinity for moisture.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer acknowledged existing collaborators/partners appeared to be engaged and recommended that the team should also include at least one automotive OEM and an adhesive supplier.

Reviewer 2:

The reviewer indicated that the planned work with Eaton sounds good and recommended more interaction and cooperation with the adhesive suppliers.

Reviewer 3:

The reviewer indicated an understanding of the reserve that the team has maintained and suggested that this project would gain acceptance if it had more partners.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer liked the way the project is advancing and hopes the present momentum can be maintained to the end of the project.

Reviewer 2:

The reviewer commented that the planned work with Eaton sounds good.

Reviewer 3:

The reviewer stated that the project team seems to have a good understanding of technical hurdles and cautioned to not simply assume that what the team learns will apply to other adhesives, further recommending the research should move away from nylon and focus on adhesives to be specified by automotive representatives.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer affirmed that an adhesive that could be easily disbonded or refreshed under carefully controlled conditions would be a boon to assembly of dissimilar lightweighting materials, pointing out that it is difficult or impossible to use more conventional joining techniques for assembling many lightweight material combinations, and concluding this could speed more rapid implementation of lightweight materials.

Reviewer 2:

The reviewer noted that enabling the bonding of fiber reinforced composites to metal and/or composite will get to lighter structures than presently achieved.

Reviewer 3:

The reviewer confirmed that joining of composites to steels and Al is a key enabler for lightweight designs.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated resources were insufficient, recommending the team should include the current car industry participation and also add other industries where bonding is a significant part of their businesses.

High-Strength Electroformed Nanostructured Aluminum for Lightweight Automotive Applications: Shiyun Ruan (Xtalic Corporation) - lm089

Presenter

Shiyun Ruan, Xtalic Corporation.

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

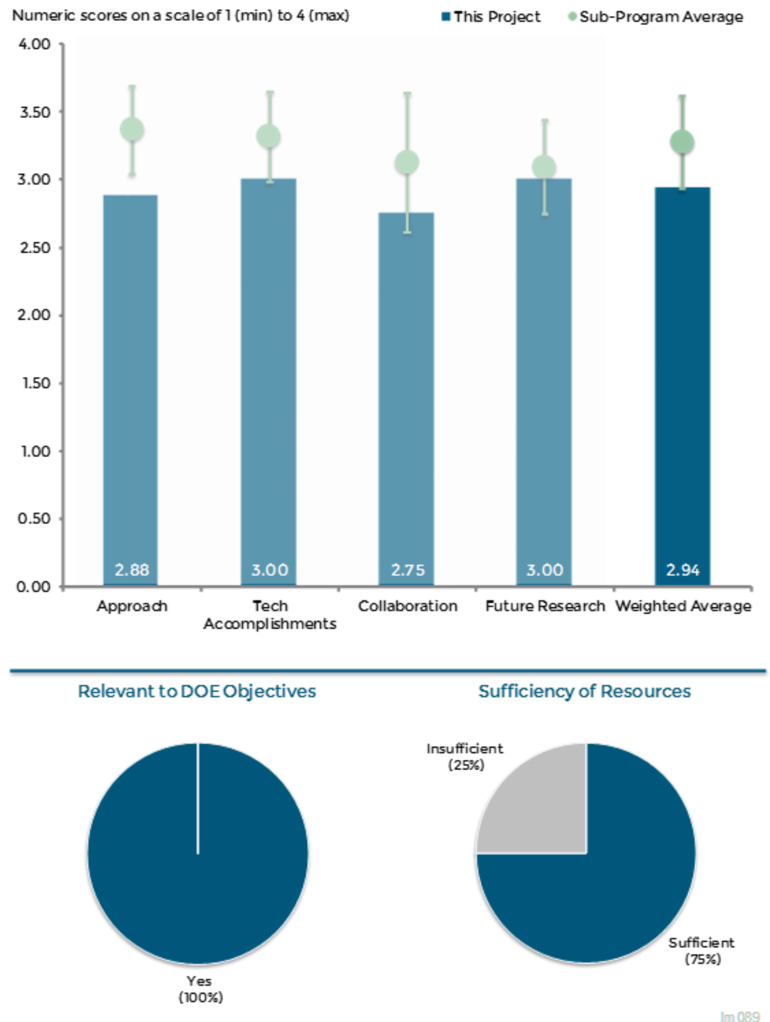


Figure 6-15 High-Strength Electroformed Nanostructured Aluminum for Lightweight Automotive Applications: Shiyun Ruan (Xtalic Corporation) – Lightweight Materials

Reviewer 1:

The reviewer acknowledged that the approach to the work appears very good including the application of a systematic attack on the key issues and a determined approach to the challenges that are coming up.

Reviewer 2:

The reviewer found this to be a very interesting approach and further offered that it will be interesting to see if the technique can be successfully scaled up to produce sheet on a scale needed for automotive applications.

Reviewer 3:

The reviewer acknowledged that electrolytic deposition of Al to form sheet is certainly a stretch to accomplish, and is novel, but emphasized that there are many remaining challenges that need to be overcome.

The reviewer encouraged the team and project to complete and present a detailed comparison of the project material fabrication methods to current conventional sheet fabrication methods. The reviewer offered the possibility to use as metrics the speed and cycle time for producing a one millimeter Al sheet processed from an ingot to a coil of sheet with production cycle time and process energy considerations. The reviewer further suggested the comparison of conventional to the electrolytic processes relating to technical challenges and costs. The reviewer offered a possible comparison of the properties of the project material to that of Al alloy, with zinc as the primary alloying element (7075 aluminum (Al)) which already has comparable strength and for which there is a baseline metric on-cost available for comparison to these aerospace alloys.

Reviewer 4:

The reviewer cautioned that the project appears to ignore the alloy component cost and processing costs related to energy content and line length. The reviewer further suggested that the process may prove to be feasible but may be akin to titanium in a cost arena. The reviewer judged that in the end you get 600 mega Pascals, 8% elongation for an Al alloy which has high cost due to energy use and alloy content resulting in a high carbon footprint and a material that is not recyclable due to alloy content.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer found progress on the technical issues appears to be quite strong.

Reviewer 2:

The reviewer praised very good progress considering the short time the project has been underway.

Reviewer 3:

The reviewer noted that the project is progressing towards first year go, no-go decision with the primary focus on chemistry and pointed out a need be focused on alloy cost and energy content.

Reviewer 4:

The reviewer encouraged that producing a six-foot by six-foot panel was a good start, noting it would have limited testability in a true stamping process. The reviewer therefore suggested either a roll formed or stamped aluminum-manganese (Al-Mn) door intrusion beam as a better starting target application compared to the objective target of bumper beam, offering that a sheet section of electrolytic Al-Mn alloy that is six feet wide and three feet long could potentially be roll formed or stamped door intrusion beam.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer applauded the excellent collaboration. The reviewer further suggested keeping this up, concluding that, as a startup, the collaboration is essential to going further toward getting the electrolytic sheet further processed into testable components in a functional product.

Reviewer 2:

The reviewer acknowledged the collaboration properly includes an automotive OEM and can sheet rolling Tier 1 supplier and suggested that adding a collaborator with expertise in electroplating is needed.

Reviewer 3:

The reviewer observed that it appears that the project is currently only an Xtalic nanostructured metals corporation effort, pointing out that the project has not yet progressed to a point where Fiat Chrysler Automobiles (FCA) involvement is needed and voiced the expectation that the interaction will increase in the future.

Reviewer 4:

The reviewer found that the collaboration was not described in detail making it difficult to provide a detailed assessment of the degree and effectiveness of the collaboration of the work. The reviewer found no concerns evident and further offered that the project appears to be at a relatively early stage, and concluded that a more accurate assessment should be possible in subsequent reviews. The reviewer further suggested to improve the assessment of the collaboration aspect, the project financing should be described in depth such as who is paying for what and how much is cash versus in-kind, concluding that this sort of detail is always useful in describing the degree and effectiveness of the collaboration in a large complex project.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer considered the decision gates to be good, emphasizing that they include cost targets, which are critical to commercial applications. The reviewer offered the value of $2 per pound of vehicle weight saved as an example metric used.

Reviewer 2:
The reviewer considered it a good plan and follow through to continue to compare and relate the development to current production sheet manufacturing processes.

Reviewer 3:
The reviewer observed that with the project at such an early stage it is likely much too early to assess the future directions that will, or should be taken. The reviewer further acknowledged that the team appeared to understand the challenges that the project faces and expressed confidence that the project team would be able to provide a more comprehensive view of their vision and future directions in the review of the project in the upcoming year.

Reviewer 4:
The reviewer observed that Xtalic appears to know what needs to be done to be successful in producing the Al sheet for the project, and expressed concern that the team has not fully comprehended what will be needed to scale up or to evaluate the cost of using their material in place of the incumbent material and related processes.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer concluded that the potential for weight reduction of the work appears to be substantial and is certainly aligned with the objectives of the DOE.

Reviewer 2:
The reviewer offered that increased use of high-strength Al will help reduce vehicle mass.

Reviewer 3:
The reviewer acknowledged that high strength Al is critical to achieving DOE objectives.

Reviewer 4:
The reviewer offered that further development of lightweight Al sheet is strategic and necessary to meet the DOE VTO objectives in transportation light–weighting.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer concluded the funding is insufficient suggested that there was an additional need for budget for a cost modeler to develop cost model of electro-formed sheet processing in order to set alloy cost targets. The reviewer warned that the cost target of $2 per pound of vehicle weight saved does not provide much room for alloy costs and processing costs.

Reviewer 2:
The reviewer commented that this project looks to be appropriately funded.

Reviewer 3:

The reviewer observed that the project is at a relatively early stage and little information on the project financing was offered, concluding it was difficult to provide an assessment of the adequacy of the resources available. The reviewer offered that because the presenter did not identify any funding issues it was concluded that the resources were adequate.

Technical Cost Modeling for Vehicle Lightweighting: Tony Mascarin (IBIS Associates) - lm090

Presenter

Tony Mascarin, IBIS Associates.

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

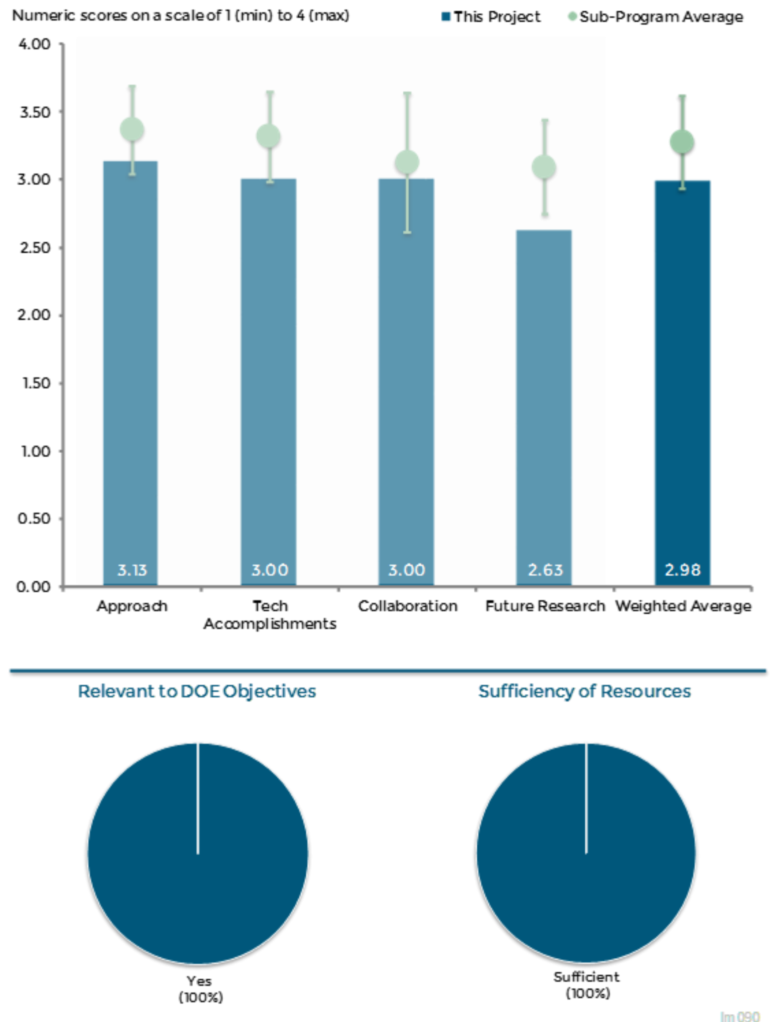


Figure 6-16 Technical Cost Modeling for Vehicle Lightweighting: Tony Mascarin (IBIS Associates) – Lightweight Materials

Reviewer 1:

The reviewer commented that the approach is very sound and it has considered the many studies conducted so far.

Reviewer 2:

The reviewer found the approach of technical cost modeling appropriate for the investigation, and cautioned that there is little confidence in the projected costs of materials and manufacturing processes which are not yet in high volume production.

Reviewer 3:

The reviewer found the approach stated in the presentation is reasonable, but judged that there were not sufficient details provided on the assumptions required for costing. The reviewer further found the elements in consideration reflecting on costs were not well described. The reviewer suggested that because much of the study includes the critical review of prior body of work conducted by other organizations, it would be prudent for IBIS to describe how the information was organized for critical review and assess the numbers accordingly as though the team was responsible for standing behind the generated cost values. The reviewer suggested that sanitized material cost, conversion cost, assembly cost, and labor cost could have been provided from the other programs. The reviewer further suggested that because this was the first review at the DOE, it would have been important to spend a bit more time describing the key outputs that were generated in the study.

Reviewer 4:

The reviewer found that modeling of the technical cost considering a value of dollars per pound of vehicle weight saved was too obscure of a target for a car vendor to simply explain to the customer.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer praised the team for completing the project as promised with the cost details based on the available information. The reviewer pointed to the results indicating customer expectations for power, acceleration, customer features, and luxury would need to change to achieve even a 30% weight reduction as a significant finding.

Reviewer 2:

The reviewer found it was very difficult to comment on technical accomplishments and was not clearly understanding the approach and what the relevance of final numbers presented. The reviewer said carbon fiber costing could have been explained better offering that the number of vehicles produced for BMW i3 and costing associated with that vehicle is much different than the costing of similar size vehicle at higher production volumes. The reviewer further pointed out that the integration of carbon fiber parts into an existing plant that utilizes steel and Al joining and the related cost impacts were not described.

Reviewer 3:

The reviewer calculated that the analysis had indicated the cost of reducing the first 30% of mass from the average 3,300 lbs. vehicle is approximately $3,500, resulting in a cost average of $3.50 per pound of vehicle mass reduction. The reviewer pointed out that further reduction beyond 30% at a cost of $3.42 per pound is not a feasible selection. The additional cost estimate needs to be higher than $3.50 pound.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer commented that collaboration with others appeared reasonable and suggested it would have been nice to understand the details behind the collaboration data that were provided to IBIS, such as comparison of existing plants to new plants and the assumptions used for material cost, conversion costs and other parameters.

Reviewer 2:

The reviewer commented that the team claims to have collaborated with OEM vehicle design engineers and the Multi Material Lightweight Vehicle (MMLV) project team to understand costs reductions in customer features and future scenarios.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer said that the project work is done on time and recommended no future work should be required here. The reviewer further stated that future cost models on carbon fiber are not appropriate for DOE funding because the drive for fuel economy improvements will drive the commercial cases.

Reviewer 2:

The reviewer simply noted the end of the project.

Reviewer 3:

The reviewer suggested that it would have been good if IBIS stated the assumptions that they were using for the identified research areas in particular technical process cost modeling and how those assumptions derived the future research areas.

Reviewer 4:

The reviewer mentioned that the project tries to yield estimates on additional costs of lightweighting yet only provides one sentence relating to the gas saving of 7% fuel saving for a 10% weight reduction. The reviewer pointed out that this last number also depends on the efficiency of the engine, the transmission, the road conditions and other factors not considered and suggested a new approach to that larger difficult problem should be establish, with the help of the car makers, the approach carmakers would like to use to present such material to their customers.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer applauded as a significant finding that the customer expectations for cars would need to change to achieve even a 30% weight reduction.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

No comments were received in response to this question.

Phase Transformation Kinetics and Alloy Microsegregation in High-Pressure Die Cast Magnesium Alloys: John Allison (University of Michigan) - lm091

Presenter

John Allison, University of Michigan.

Reviewer Sample Size

A total of four reviewers evaluated this project.

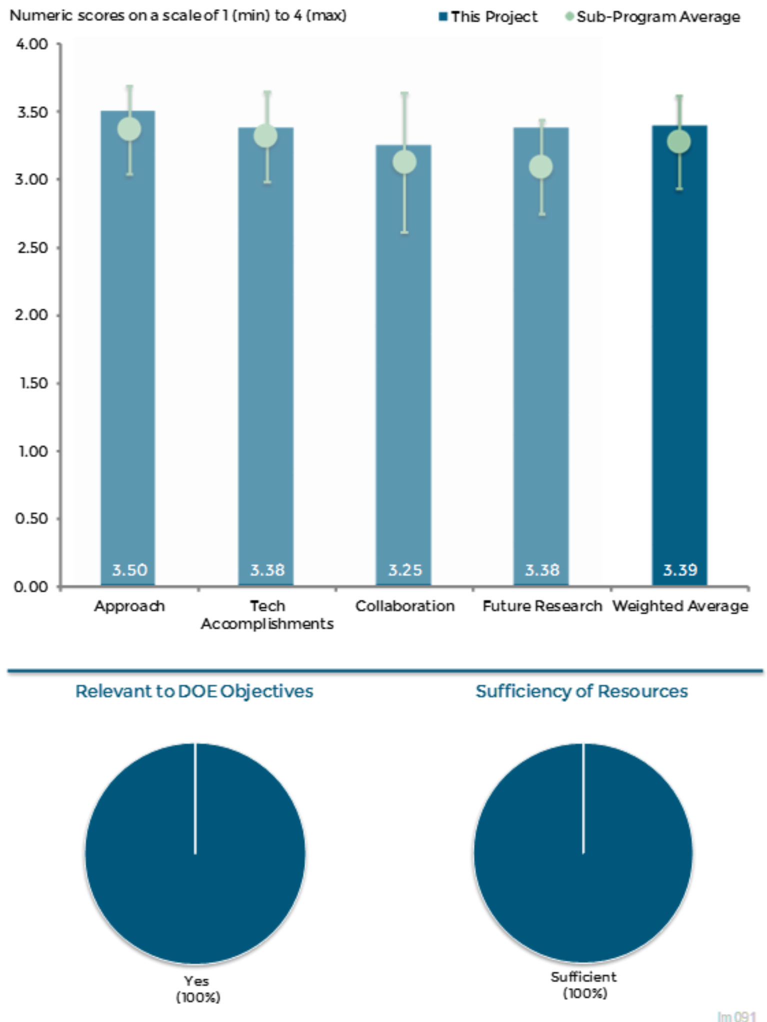


Figure 6-17 Phase Transformation Kinetics and Alloy Microsegregation in High-Pressure Die Cast Magnesium Alloys: John Allison (University of Michigan) – Lightweight Materials

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commented that the project presented careful and detailed macro-segregation analysis in high pressure die casting (HPDC) Mg alloys, and commented that the data being generated in this project will be required for future ICME projects on HPDC Mg.

Reviewer 2:

The reviewer commented that it was a clearly articulated approach with well-defined tasks.

Reviewer 3:

The reviewer commented that the analysis of multiple alloys with different elements is well planned.

Reviewer 4:

The reviewer questioned the uncertainties of the chemical concentration measurements in the microstructure, and whether is it a function of how close you are to the edge of the phase.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer commented that the project team seems to be on a good track, with experiments complimenting the modeling.

Reviewer 2:

The reviewer commented that the team completed extensive work in experimentation and modelling.

Reviewer 3:

The reviewer questioned if any inferences can be drawn from of all of the data acquired so far to in-service mechanical performance of HPDC and how heat transfer coefficients were measured. The reviewer pointed to Slide 17, and suggested an improvement to provide some indication as to how the various parameters are acquired. The reviewer further offered the example that these parameters were possibly acquired from other programs, or computed via an ICME approach, and suggested the team present how all of the results tie together to suggest improvements to HPDC Mg alloys.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer praised that there appears to be excellent engagement and involvement of researchers at Ford, the University of Michigan, Ohio State University and Tsinghua Universities.

Reviewer 2:

The reviewer commented that the partners are Ford Motor Company, Ohio State University and Tsinghua University.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer commented that things look good as the project team is getting samples and the analytical capabilities seem to be working.

Reviewer 2:

The reviewer commented that the plan for future work has been clearly laid out.

Reviewer 3:

The reviewer commented that micro segregation as well as macro segregation are significant in die cast due to extreme rapid cooling rates and high velocity and suggested that efforts should be made to identify the effects of these process parameters.

Reviewer 4:

The reviewer cautioned that the development of micro-models for microstructure prediction may be unrealistic and it seems to be a very tall order for this project. The reviewer questioned whether microstructure prediction should be attempted only with a thermodynamic approach.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer commented that HPDC is going to be a needed technique for these materials to be used commercially, and suggested this effort needs to be conducted in parallel with development of better performance alloys.

Reviewer 2:

The reviewer commented that improved ability to predict characteristics of HPDC Mg will improve the ability to optimize the design and reduce the mass of cast components, the predominant form of Mg currently used in automobiles.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

No comments were received in response to this question.

In-Situ Investigation of Microstructural Evolution During Solidification and Heat Treatment in a Die-Cast Magnesium Alloy: Aashish Rohatgi (Pacific Northwest National Laboratory) - lm092

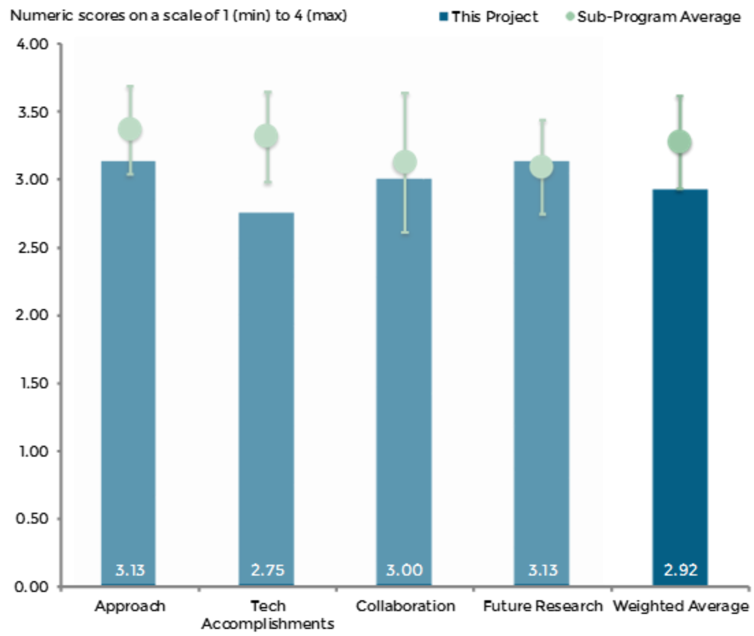
Presenter

Aashish Rohatgi, Pacific Northwest National Laboratory.

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.



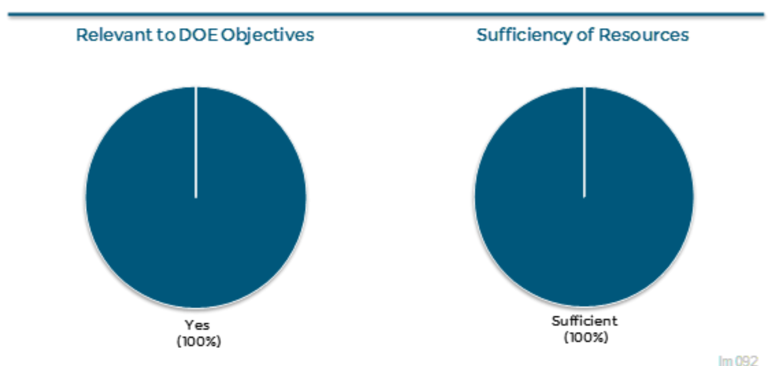


Figure 6-18 In-Situ Investigation of Microstructural Evolution During Solidification and Heat Treatment in a Die-Cast Magnesium Alloy: Aashish Rohatgi (Pacific Northwest National Laboratory) – Lightweight Materials

Reviewer 1:

The reviewer commented that it was a very good integrated approach comprehending modeling and experimental results in studying solidification and heat treatment.

Reviewer 2:

The reviewer applauded the novel approach to measuring diffraction data for Mg and Mg-Al alloy ($Mg_{17}Al_{12}$) in an electron microscope.

Reviewer 3:

The reviewer acknowledged the use of transmission electron microscopy (TEM) for the in-situ solidification experiments is an excellent idea and cautioned that measuring the temperature will be a challenge.

Reviewer 4:

The reviewer criticized that the inability to measure the temperature of the sample during the experiment, or at the temporal scale, to look at the cooling and solidification kinetics, is a major problem and will potentially negate any experimental observations coming out of this project. The reviewer further commented that thin film and free surface artifacts inherent in TEM experiments and the effect of the silicon nitride substrate on crystallization are not terribly well addressed.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer commented good progress.

Reviewer 2:

The reviewer cautioned, that unless the project team can work out the kinks, this project might be in trouble.

Reviewer 3:

The reviewer questioned where the material parameters in the model on Slide 13 originated from, and commented that on Slide 16, it appears that two potentials were examined, both of which were found to be deficient, with the first giving negative components of the elasticity tensor and the other requiring modifications by the Principal Investigator (PI) to get close to density functional theory (DFT) values. The reviewer further questioned the point of the potentials and suggested that if one were to change the alloy content in the Mg alloy, then the potential approach would again be problematic and one would have to again appeal to DFT. The reviewer suggested to discuss these issues with National Institute of Standards and Technology (NIST). The reviewer requested on Slide 17 to include temperatures at which the reported data was acquired with special focus on experimental data. The reviewer further questioned whether the project is comparing zero Kelvin DFT results with room temperature experimental results and commented that the same question applies for data on Slide 18. The reviewer was concerned how to relate the data on Slides 17 and 18 to support the main objective of this project, which is to measure in situ kinetic information of Mg die castings. The reviewer further stated that that these topics are completely unrelated with substantive details on the various models. The reviewer questioned whether elastic properties support understanding of microstructural evolution in non-equilibrium Mg die cast microstructures, and has the same question for the effects of defects and vacancies. Finally, the reviewer inquired about how the kinetic Monte Carlo method for simulating microstructural evolution of heat-treated sputtered films ties in.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer commented that collaborations were limited to one, and their results are preliminary.

Reviewer 2:

The reviewer commented that ESI appears to be actively engaged in execution of the project and incorporation of its findings in ProCAST casting simulation suite.

Reviewer 3:

The reviewer questioned what ESI is contributing to this project, such as the ProCAST simulations for example.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer commented that the plan is good and hoped the team can get the scope working and figure out how to measure the temperature of the sample spatially and temporally.

Reviewer 2:

The reviewer commented that in Slide 12, problems with focused ion beam (FIB) are identified and questioned whether the current approach involves using sputtered Mg-Al and Mg-Al-Zn films for heat treatment work.

The reviewer further questioned what the approach is to determine diffusion coefficients and effective migration barriers as a function of Al concentration and temperature. The reviewer said Slide 21 stated that the technical barrier identified pertains to inability to measure temperature inside the DTEM, then Slide 22 says perform DTEM experiments. The reviewer questioned how the barrier is to be overcome.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer commented that solidification processing of Mg is the first way this class of alloys will be incorporated into lightweight vehicles, and the kinetics and microstructural studies during rapid solidification are relevant and needed.

Reviewer 2:

The reviewer commented that Mg is a potential lightweight replacement material for heavier ferrous and non-ferrous alloys in automotive structures.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

No comments were received in response to this question.

High-Throughput Study of Diffusion and Phase Transformation Kinetics of Magnesium-Based Systems For Automotive Cast Magnesium Alloys: Alan Lou (Ohio State University) - lm093

Presenter

Alan Lou, Ohio State University.

Reviewer Sample Size

A total of four reviewers evaluated this project.

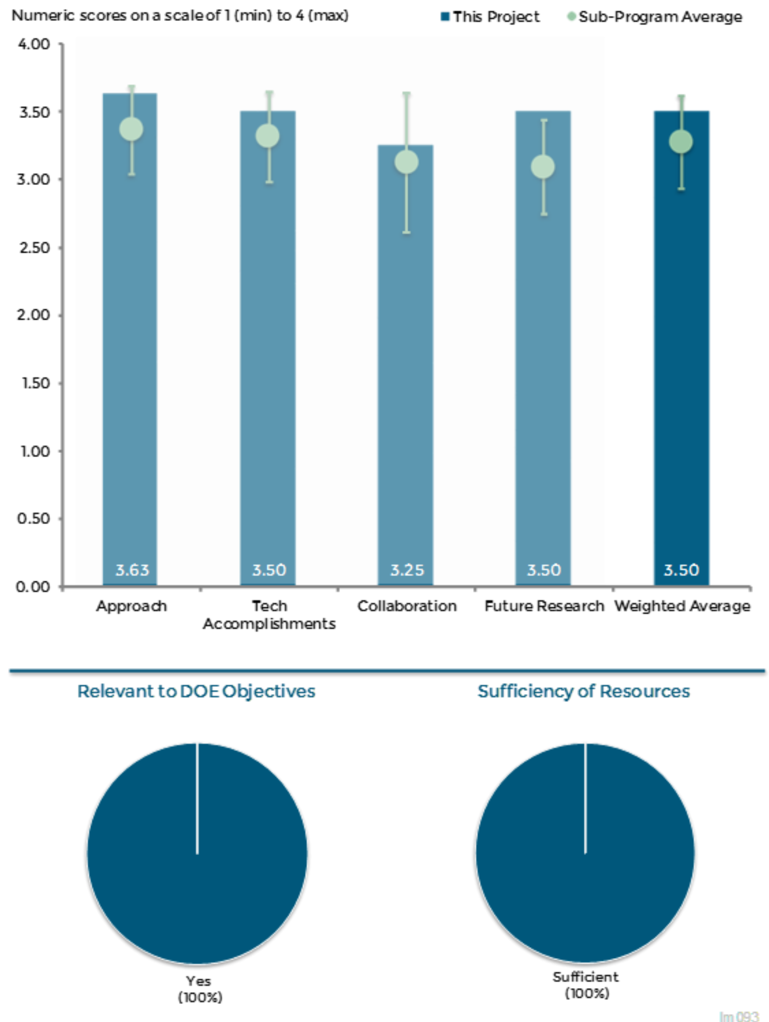


Figure 6-19 High-Throughput Study of Diffusion and Phase Transformation Kinetics of Magnesium-Based Systems For Automotive Cast Magnesium Alloys: Alan Lou (Ohio State University) – Lightweight Materials

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer applauded the great experimental approach for generating much needed liquid diffusion data, adding that this is a tough problem and the experiments appear to be novel and sound.

Reviewer 2:

The reviewer commended that a diverse and detailed approach was established.

Reviewer 3:

The reviewer acknowledged the nice experimental technique produces a lot of data with every run and pointed out that the effect of hydrostatic pressure when the central metal melts while rigidly encapsulated by the alloying solid metals was not really discussed or explained adequately during the question and answer session. The reviewer suggested that the project team needs to address this explicitly and see if there is an effect on the data.

Reviewer 4:

The reviewer offered that the solution and precipitation of particles is controlled by diffusion and the mechanism is not well understood for Mg alloys and further relayed that this is one of the works focused on this subject funded by DOE. The reviewer commented that the effort to measure both liquid phase and solid phase diffusion of different elements is very well thought out.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:
The reviewer commented that this program will generate a ton of diffusion data for the modelers to use.

Reviewer 2:
The reviewer commented very good progress in experimentation, simulation and validation.

Reviewer 3:
The reviewer commented that in the liquid phase diffusion experiments, for Al-Mn the evaluation is carried out at 600°C, where none of the elements are liquid. More explanation is needed.

Reviewer 4:
This reviewer explained that comments applied to the uploaded version of this presentation because another version was actually presented at the 2015 DOE AMR by the PI, with Dr. Luo's name being the only name on the cover slide. Referencing Slide 20, this reviewer asked which part of the diffusion coefficient versus 1/T curves pertain to liquid and which pertain to solid. If solid is included in the diffusion coefficient versus 1/T data, the reviewer inquired why are there not two curves to account for diffusional anisotropy of impurities in HPC Mg (via vacancy diffusion, for example). It appeared that the data in Slide 20 was computed from the literature and does not show results from the measurements conducted in this project. In Slide 22, which details the precipitation model, the reviewer said that it would be helpful to have a bit more detail as to which of the model parameters (e.g. material properties) can be measured, and which result from fitting to experimental data. The reviewer also referenced Slide 23 and inquired about how good the data was fitting and requested that this be quantified.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer commented it looks like things are working well

Reviewer 2:
The reviewer offered that this is a basic science project and it is understandable that the partners are more on the academic side than industry.

Reviewer 3:
The reviewer cautioned that it appears that Ohio State University is doing the work and simply conveying information to other partners rather than actively engaging those partners.

Reviewer 4:
The reviewer questioned what GM is providing to the project other than alloy suggestions, and offered that it is likely that GM could support the project with die casting facilities and measurement capabilities. The reviewer requests to see a more definitive role for GM in this project. The reviewer relayed that Computherm is the other collaborator.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer acknowledged that a well identified multi-prong approach has been laid out.

Reviewer 2:
The reviewer offered high expectations for future work.

Reviewer 3:
The reviewer commented on the team’s presentation of the Sheil model and the fact that phase transformation kinetics in Mg alloys are not well understood, expressing concern that the future effort to resolve was not provided in sufficient detail and requests more detail on how the project will specifically address this issue.

Reviewer 4:
The reviewer commented that it may be useful to see what will be the diffusion in alloys as this can be studied in future.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer commented that the benefit is in long-term, the understanding of diffusion mechanism, may lead to development heat treatable Mg alloys that can be used in place other high-strength materials such as steel.

Reviewer 2:
The reviewer commented that diffusion data for the alloying elements of Mg is vital to the accurate modeling of microstructural development during hot processing of these lightweight alloys.

Reviewer 3:
The reviewer commented that this project focuses on lightweight Mg cast alloys.

Reviewer 4:
The reviewer commented that this is an enabler for increasing the use of Mg by improving modelling capability and accuracy.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

No comments were received in response to this question.

Microstructure and the Corrosion/Protection of Cast Magnesium Alloys: Karl Sieradzki (Arizona State University) - lm094

Presenter

Karl Sieradzki, Arizona State University.

Reviewer Sample Size

A total of three reviewers evaluated this project.

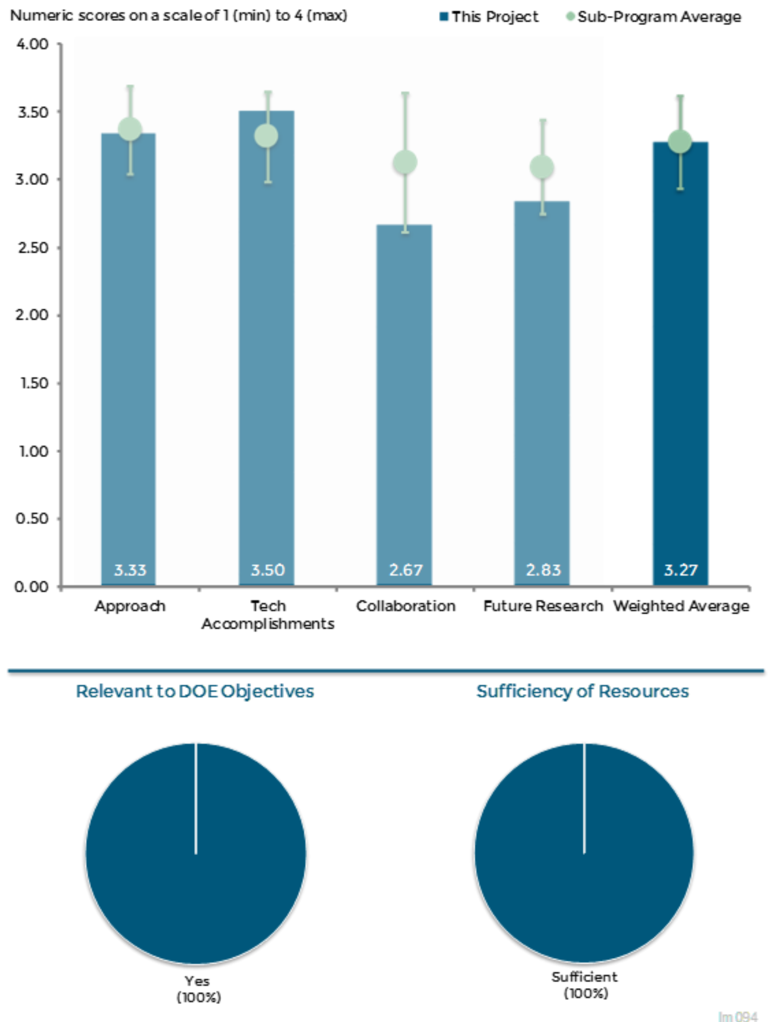


Figure 6-20 Microstructure and the Corrosion/Protection of Cast Magnesium Alloys: Karl Sieradzki (Arizona State University) – Lightweight Materials

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer surmised that this project is aimed at studying the corrosion of cast Mg alloys and it appears to be a very well organized and properly conducted piece of work.

Reviewer 2:

The reviewer reported the approach was not clear and suggested that the presenter more clearly explain how the various tasks will fit together to generate the predication model, develop the basic understanding of oxidation and corrosion, and how this leads to the development of corrosion protection schemes.

Reviewer 3:

The reviewer commented that it is difficult but necessary effort and very good scientific work. The reviewer suggested to adapt the communication more to people not in the line of work of the authors.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer applauded the progress is outstanding, pointing to the new measurement protocol that appears very effective. The reviewer related that a lot of data was available and that the slides were not as clear as the presenter. The reviewer offered, for example, that one slide mentioned that EDS probe measures both electrically connected and disconnect Al, which sounds good, but the presenter said that one cannot distinguish between these two effects, which sounds bad. The reviewer found the slides too technical and detailed on the data and did not provide enough on the conclusion and implications of the data.

Reviewer 2:

The reviewer offered that given the type of study that the work presented represents, the work appears to be of fine quality with a highly repeated and confirmatory set of results and a well-organized program.

Reviewer 3:

The reviewer commented that overall the system too complicated and is concerned that the presented hypotheses may not capture the real effect and offered that maybe this will come in a follow-on project.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer commented it appeared that the collaboration is going well with the work of each partner acknowledged on the various slides that were presented.

Reviewer 2:

The reviewer acknowledged this is a very good collaboration to cover a lot more cases and suggested there is a need to add Arizona State University's and the University of Toronto's roles and work to the collaboration slide. The reviewer applauded the advisory aspect of University of Toronto and would like to know more on why they are involved and what their contribution is.

Reviewer 3:

The reviewer affirmed this may be a good academic collaboration but the fact that the industry is absent is a real problem. The reviewer suggests that such a work is necessary and, as presented, should be moved to the DOE Office of Basic Science.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer commented that the future work slide is excellent and will hopefully be better when the approach slides are improved.

Reviewer 2:

The reviewer commented that the outline of future work is better than satisfactory but that without an industry presence there is concern about the future of the project.

Reviewer 3:

The reviewer commented that not very much was said about the future work but it does appear that a set of future steps is under development. The reviewer suggested that the presentation at the next review focus less on an extensive review of highly detailed scientific results and more on the project performance and future plans, perceived barriers and an overview only of key accomplishments, which are of primary importance to DOE's vehicle weight reduction goals.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer commented that Mg is likely a core part of future vehicle technology and this work does support DOE's objective.

Reviewer 2:

The reviewer commented that corrosion is a large barrier to Mg adoption and funding to overcome this barrier is appropriate.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented that funding appears sufficient to achieve goals.

Reviewer 2:

The reviewer commented that nothing on the budget was presented except the global financing of the entire project and so it is difficult to fully assess the adequacy of the resources available.

A System Multiscale Modeling and Experimental Approach to Protect Grain Boundaries in Magnesium Alloys from Corrosion: Mark Horstemeyer (Mississippi State University) - lm095

Presenter

Mark Horstemeyer, Mississippi State University.

Reviewer Sample Size

A total of three reviewers evaluated this project.

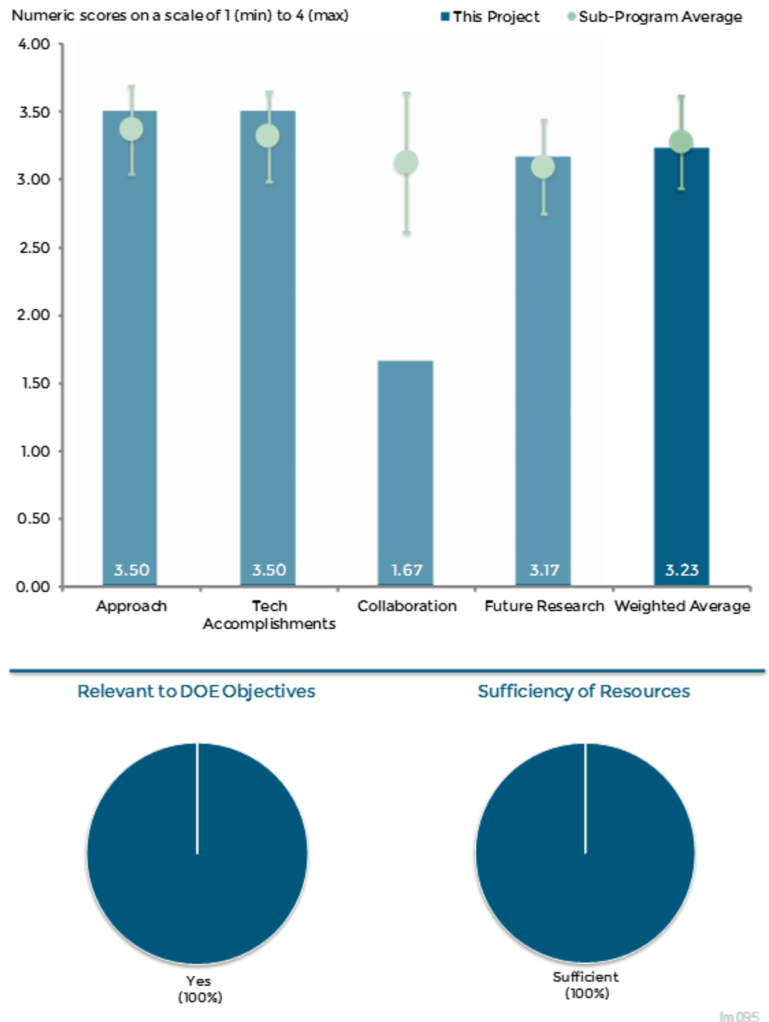


Figure 6-21 A System Multiscale Modeling and Experimental Approach to Protect Grain Boundaries in Magnesium Alloys from Corrosion: Mark Horstemeyer (Mississippi State University) – Lightweight Materials

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commented the overall approach seems to be highly integrated and well planned among a group of experienced and talented researchers working with the proper equipment.

Reviewer 2:

The reviewer commented that the approach is clearly outlined and very well-articulated and applauded the high degree of interdependence between the various models. The reviewer recommended adding a risk analysis and risk mitigation plan considering the case that one or more of the models proved not to behave as expected resulting in poor validation or the case where the data is more difficult to collect resulting in a large variation in results. Additionally, the reviewer recommended confirming metrics of model quality and risk considering the probability of occurrence and impact.

Reviewer 3:

The reviewer commented that it is difficult but necessary effort and very good scientific work. The reviewer suggested adapting the communication more to people not in the line of work of the authors.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer commented that technical accomplishments were very systematic and showed outstanding progress.

Reviewer 2:
The reviewer commented that the work appears to have been quite successful.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer commented that collaboration between Mississippi State and University of Illinois at Urbana-Champagne appears to be highly integrated and thus quite successful. The reviewer offered that industry participation should be considered as it can be of great help in ensuring that projects are going in a useful direction and that the results are likely to be adopted in the marketplace, further commenting that industry involvement is really the only way for the results to have any real impact on vehicle weight, which is the whole idea of the DOE program.

Reviewer 2:
The reviewer commented that no information was found on collaboration and that this slide is missing from the presentation so there is no idea who is doing what.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer pointed out that this project is nearly complete and the team said relatively little about future plans.

Reviewer 2:
The reviewer indicated that the future work is clear, because the approach was so well articulated and would like more information on the model validation such as what alloys will be validated, how are they determined, and what are the metrics and values to be used to demonstrate success.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer commented that future vehicles must be lighter to save fuel and a core component of the weight reduction effort is the introduction of lower density materials such as Mg.

The reviewer further pointed out that the present project is aimed at making the widespread use of Mg in mass-market automobiles much more feasible and therefore does support the DOE objectives to reduce vehicle weight.

Reviewer 2:
The reviewer commented corrosion is a large barrier to Mg adoption, and funding to overcome this barrier is appropriate.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer commented that little was said about the financing of the project so it is difficult to assess the adequacy of the funds on the conduct of the work.

Reviewer 2:
The reviewer commented that funding appears sufficient to achieve goals.

Corrosivity and Passivity of Metastable Magnesium Alloys: Guang-Ling Song (Oak Ridge National Laboratory) - lm096

Presenter

Guang-Ling Song, Oak Ridge National Laboratory.

Reviewer Sample Size

A total of three reviewers evaluated this project.

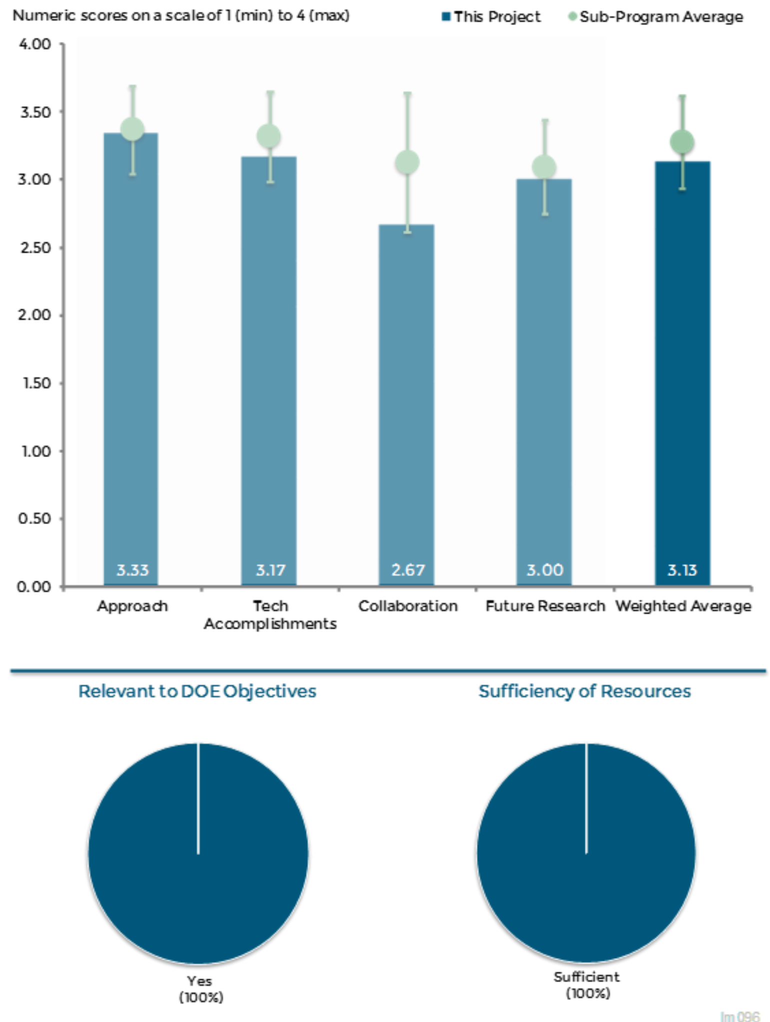


Figure 6-22 Corrosivity and Passivity of Metastable Magnesium Alloys: Guang-Ling Song (Oak Ridge National Laboratory) – Lightweight Materials

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer reported that the approach seems to be systematic and the result of good planning by knowledgeable team members; however, the presentation concentrated largely on technical results and relatively little was said about how the project is actually being conducted, so it difficult to comment on the overall effectiveness of the approach.

Reviewer 2:

The reviewer applauded the commendable approach to make stainless Mg to improve corrosion resistance, and requested clarification on whether the stainless Mg is created by using a doping element with limited solubility or by creating a new phase.

Reviewer 3:

The reviewer reported that the approach is clearly outlined and very straightforward, but not as interesting as the basic idea offering that it is primarily an empirical data collection study. The reviewer further acknowledged that the using a sputtering method of creating alloys is a good idea.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer related that it appears that a good deal of technical data has been obtained and several key pieces of new knowledge have resulted from the work; however, a comparison of expected milestones and results achieved was never presented and so it is challenging to state for sure just how well the project worked.

Reviewer 2:
The reviewer praised the activity citing excellent work and accomplishments in the first year.

Reviewer 3:
The reviewer relayed that the comparison between Mg-titanium (Ti) and Mg-chromium (Cr) show promise to be very interesting and either one might resolve the Mg corrosion issue.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer commented that the collaboration is explained and is clear for this project.

Reviewer 2:
The reviewer commented that the team appears to be good and seems to work well together; however, the reviewer also expressed to be un-convinced that the industry consultant had any input in the presented material and offered that a real industry presence is a necessity on a project to result in some real applications.

Reviewer 3:
The reviewer commented that the members of the research team were flashed up on the screen but nothing further was said about how the various entities are involved in the work the budget split-up, or the tasking assignments. The reviewer acknowledged, in fact, that good results have been obtained, suggesting that the collaboration is actually working, but could not be sure.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer commented that the project is nearly completed and so the prospects for future work really refer to future, separately funded projects. The reviewer suggested to add some words about the potential for a cost-effective automotive solution as little or nothing was said about estimates of future costs.

Reviewer 2:
The reviewer observed that the future work is clear, because the approach is so straightforward.

Reviewer 3:
The reviewer found the prospects for future work are too skimpy and not detailed enough.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer explained that the work is related to reducing the corrosion of Mg alloys in automotive service and therefore is clearly is aligned with the DOE objective to reduce vehicle weight.

Reviewer 2:
The reviewer concluded that corrosion is a large barrier to Mg adoption and finds funding to overcome this barrier is appropriate, even if not all approaches will be successful. The reviewer further declared that if the problem was easy, it would have been solved by now.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer suggested it would be an improvement to see more industry involvement and more funding for the idea of stainless Mg.

Reviewer 2:

The reviewer mentioned that little was said about the budget and no issues about its adequacy were raised during the presentation.

Reviewer 3:

The reviewer commented that the funding appears sufficient to achieve goals.

Laser-Assisted Joining Process of Aluminum and Carbon Fiber Components: Adrian Sabau (Oak Ridge National Laboratory) - lm097

Presenter

Adrian Sabau, Oak Ridge National Laboratory.

Reviewer Sample Size

A total of four reviewers evaluated this project.

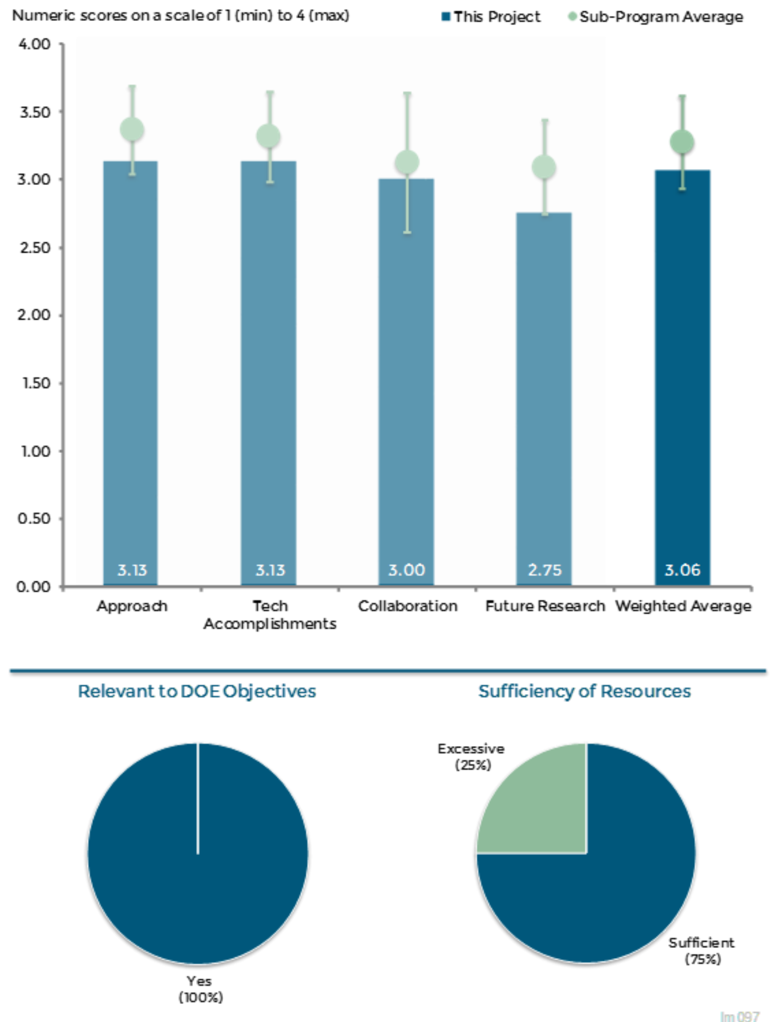


Figure 6-23 Laser-Assisted Joining Process of Aluminum and Carbon Fiber Components: Adrian Sabau (Oak Ridge National Laboratory) – Lightweight Materials

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer related that this was a novel approach to joining involving laser-assisted roughening of material surfaces.

Reviewer 2:

The reviewer commented that the approach chosen is generally good, establishing baseline information set for the raster and spot methods of surface roughening. The reviewer further stated, however, the approach could be improved with go versus no-go decision points. The approach should also comprehend typical joint configurations such as peel tests.

Reviewer 3:

The reviewer praised the idea is novel and interesting while offering that the presentation suffers from clarity. The reviewer further stated that the question and answer session required too many questions for the reviewers to clearly understand what was done. The reviewer believed the need for a slide that explains the difference between raster and spot. Raster is mentioned for the first time on Slide 14. The reviewer questioned whether Slide 7 is intended to conveys the process on Al, expressing the understanding that the process is only on the composite side. The reviewer further suggested the need to explicitly state that the process is applied to both materials. The reviewer suggested the results be presented with statistical significance levels, assuming that at least two replicates were conducted for each trial and also provide military relevance because TARDEC is a co-sponsor.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer commented that there appears to have been a lot of work conducted, even more than was fully presented. The reviewer stated that some of the results appear to have been withheld because of propriety as well as patent potential, which is understandable; however, the reviewer found it difficult to assess the amount of work conducted without more disclosure.

Reviewer 2:

The reviewer commented that if the project involves joining of Al alloys in the family (Al 5XX) to carbon fiber, it seems that the team may need to be concerned about corrosion, especially for metal alloys containing Mg.

Reviewer 3:

The reviewer judged that this appears to be a needlessly high technology solution to a problem that can be addressed using conventional methods, considering it only provides marginally better performance than with conventional techniques.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer related that the collaborators are Magna, Plasan, and 3M.

Reviewer 2:

The reviewer cautioned that collaboration was limited to Magna providing material and 3M adhesive advice, and suggested that the project would improve from more collaboration with the U.S. Army and possibly automotive OEM advisors.

Reviewer 3:

The reviewer expressed that it is not obvious that collaborators have done anything more than providing materials, or providing purchased services.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer commented that future work can be improved to look at the most reasonable/efficient combination of surface preparation. The reviewer suggested a more structured approach with clear metrics, such as processing time and cost; and joint strength. The reviewer related that there appears to be seven possible combinations including the baseline, given three preparation conditions for Al and two for carbon fiber component CFC plus baseline.

Reviewer 2:

The reviewer related that it seems that the proposed surface roughening process is an extra step in joint manufacturing and questioned the feasibility from a cost standpoint. The reviewer also questioned if there is any modeling planned that would lead to an optimal design of the patterned joint interfaces via laser roughening, questioning how the geometry of the surface topography influence surface wetting of the adhesive.

Reviewer 3:

The reviewer cautioned that while corrosion is an issue for dissimilar material joints, it is not apparent that this technique would do anything but aggravate the corrosion, and suggested that because there is little apparent benefit to the use of this technique, only limited improvement in shear strength, the additional expense to document corrosion behavior appears to be a needless expense. On this basis the reviewer suggests to simply wrap up the project.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer commented that dissimilar material joining is considered one of the most important technical barriers to the multi-material lightweight vehicle.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented that funding appears sufficient to achieve goals.

Reviewer 2:

The reviewer commented that there is no apparent need to continue the work.

Brazing Dissimilar Metals with a Novel Composite Foil: Tim Weihs (Johns Hopkins University) - lm098

Presenter

Tim Weihs, Johns Hopkins University.

Reviewer Sample Size

A total of three reviewers evaluated this project.

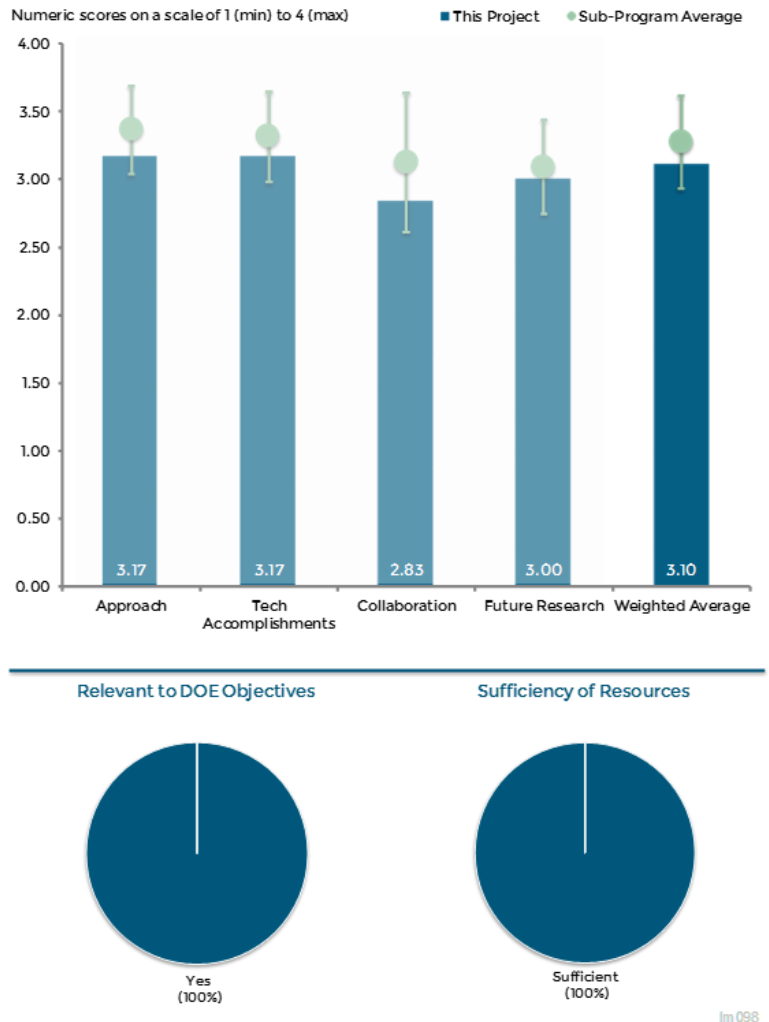


Figure 6-24 Brazing Dissimilar Metals with a Novel Composite Foil: Tim Weihs (Johns Hopkins University) – Lightweight Materials

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commended the approach as novel and acknowledged that the project is well structured and presented. The reviewer suggested that given the initial results a risk mitigation plan may be warranted for the case of failing the go, no-go criteria of 10 mega-Pascal. The reviewer also suggested a slide that shows a structured research approach, such as a series of designed experiments for identifying the particular chemistries and process parameters. The reviewer related that while the presentation was very well presented, it also is apparent that the problem is quite complex and that there is likely an optimum combination of chemicals, their quantity, reactant spacing, and foil thickness for a particular set of materials to be joined. The reviewer suggested that a fishbone or other diagram identifying the variables and their levels and how the tasks are addressing determining their optimal level would be helpful.

Reviewer 2:

The reviewer praised that the team was doing well at addressing the fundamentals of joining with the reduction-oxidation (redox) foils and suggested that the team keep in mind right from the start a vision of how and where this foil, if successful, will be used in automotive production as this could help identify suppliers or other collaborators to engage.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer commented that significant progress was made relating that lot of experiments were conducted, and a lot of information gathered and lessons learned. The reviewer judged that accomplishments were well explained and presented.

Reviewer 2:

The reviewer commented that this activity is obviously still very much a work in progress. The reviewer found it encouraging to see that moderate bond strengths can be obtained even now; however, related that it was redundant for the team to state that the bond strength depends strongly on foil chemistry and the materials being bonded because that is the thrust of this project. The reviewer encouraged the work, stating it will be interesting to see what comes from the dilution studies and optimization.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer stated that collaborations are limited at this time and suggested it may be worthwhile to reach out to other interested parties that work in the automotive research area and attend the Annual Merit Reviewer regularly as one of the OEM reviewers had a comment that the presenter acknowledged was helpful.

Reviewer 2:

The reviewer stated that it is unclear what Dr. Woll's role is in the project, and therefore collaboration, interaction and coordination are not readily apparent.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer suggested that a slide on the mathematical modeling and simulation would be good to improve the proposed research plan and suggested an improvement to the future work would also be a slide on the structured method by which the future work goals will be accomplished. The reviewer stated it may be an educational improvement to clarify what is known and is the starting point and what has been learned through this project. The reviewer also questioned if there were any statistical significance tests that have been performed

Reviewer 2:

The reviewer commented that it looks like the work to optimize dilution for the nickel oxide and copper oxide (NiO and Cu_2O) systems is well understood and will be addressed. The reviewer suggested that more work should be included to address the ability to actually apply this method to more than laboratory specimens, and to begin to address corrosion issues.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer commented that dissimilar material joining is considered one of the most important technical barriers to the multi-material lightweight vehicle

Reviewer 2:

The reviewer commented that this could potentially aid in reducing vehicle weight by facilitating joining of dissimilar metals.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented that funding appears sufficient to achieve goals.

High Strength, Dissimilar Alloy Aluminum Tailor-Welded Blanks: Yuri Hovanski (Pacific Northwest National Laboratory) - lm099

Presenter

Yuri Hovanski, Pacific Northwest National Laboratory.

Reviewer Sample Size

A total of three reviewers evaluated this project.

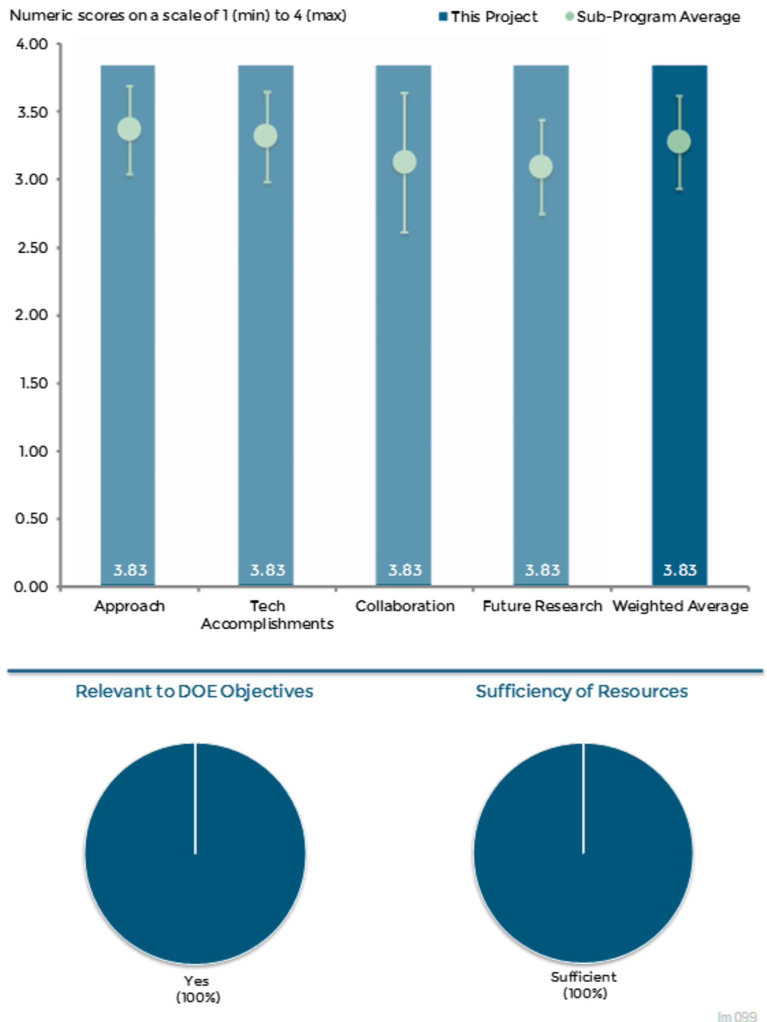


Figure 6-25 High Strength, Dissimilar Alloy Aluminum Tailor-Welded Blanks: Yuri Hovanski (Pacific Northwest National Laboratory) – Lightweight Materials

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer praised the approach as outstanding relating it includes all major tasks to overcome all barriers to adoption including cost, joint strength performance, as well as modeling and simulation that can be used by the process user to a to optimize and adapt to future changes, geometry changes, and process consistency for production readiness.

Reviewer 2:

The reviewer praised the approach of including fully the automotive supply chain and testing production intent geometries as a great approach for the project. The reviewer emphasized that the four-phase technical approach will address the critical issues with this enabling technology.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer related that the project is ahead of schedule and introducing a more complex model to enhance the accuracy of the simulation models. The reviewer related that the project team had completed initial investigation on curvilinear welding.

Reviewer 2:

The reviewer praised the results on the temperature measurements and the heat affected zone as great. The reviewer suggested it would be good in future Annual Merit Review presentations to clearly tie project technical accomplishments to the presented four-phase, multiple step project plans and noted that beginning to characterize the material properties of the friction stir welding (FSW) weld material area is highly valuable

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer praised the collaboration with the material supplier, Alcoa, the process user, TWB, and the end customer, GM, as excellent, offering that they help drive the project forward, and also identify the acceptability of the results and the desirability of certain processing conditions to help the research team identify problems that need to be overcome. The reviewer relayed the example of adding Barlat coefficients into consideration.

Reviewer 2:

The reviewer commented that there was strong collaboration throughout the automotive supply chain.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer commented that there was a strong plan for future work to address the project research.

Reviewer 2:

The reviewer suggested it would be an improvement to see a table of success metrics, values, and milestones and when they will be accomplished.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer commented that rapid, low-cost joining technologies for advanced automotive materials will help accelerate the adoption of lightweight materials.

Reviewer 2:

The reviewer commented that tailor welded Al blanks give the design engineer more flexibility to optimize the part weight.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented that funding appears sufficient to achieve goals.

Upset Protrusion Joining Techniques For Joining Dissimilar Metals: Steve Logan (Fiat Chrysler Automobiles US LLC) - lm100

Presenter

Steve Logan, Fiat Chrysler Automobiles US LLC.

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

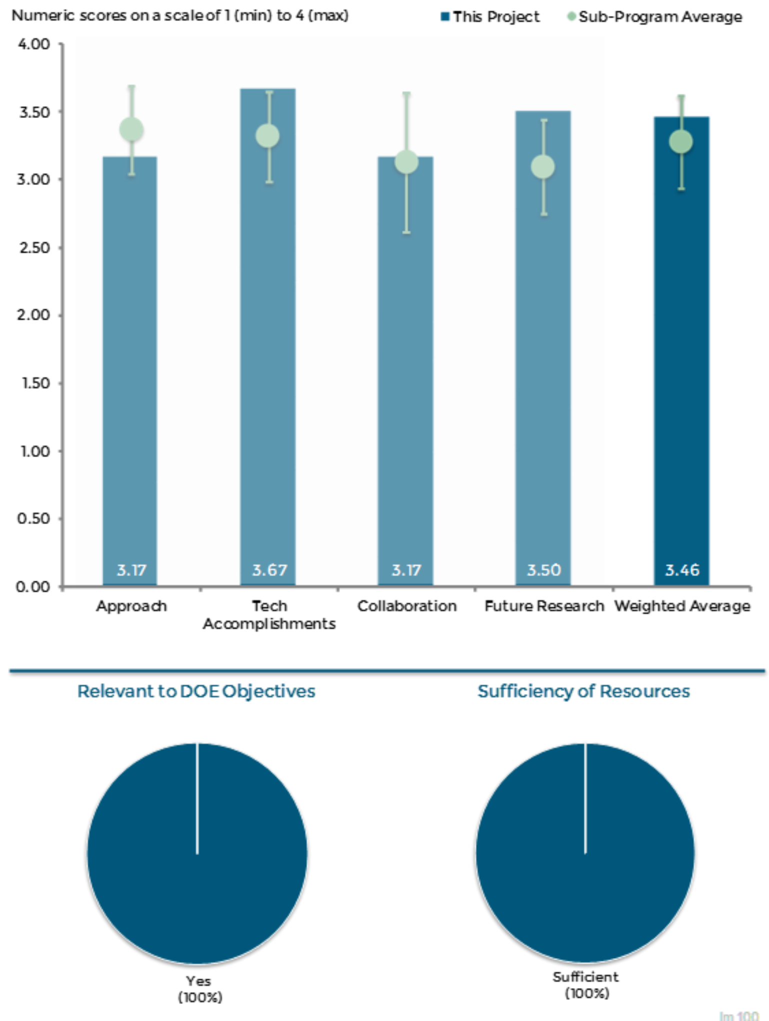


Figure 6-26 Upset Protrusion Joining Techniques For Joining Dissimilar Metals: Steve Logan (Fiat Chrysler Automobiles US LLC) – Lightweight Materials

Reviewer 1:
The reviewer said the approach to develop the upset protrusion joining technique for mixed material joints is creative and exciting.

Reviewer 2:
The reviewer commented that a challenge to the use of cast Mg is the joining to other materials. The reviewer further related that in response to this challenge, the team has developed a mechanical joining process using in-cast protrusions. The reviewer acknowledged that comparing this new technique to other mechanical bonding, self-pierce riveting (SPR), is a good idea and cautions that this process cannot be used if the material is not cast.

Reviewer 3:
The reviewer said it appears to be an important project with enough experiments to obtain reliable statistics.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:
The reviewer commented that the amount of work done is astonishing and the team should be commended.

Reviewer 2:
The reviewer explained that the qualification of the process is ongoing and it is as planned.

Reviewer 3:
The reviewer commented that the team has characterized the standard joints as a baseline for the benchmark for the future testing of mixed material joints and praised the work on the Mg to Al joins as a fantastic accomplishment. The reviewer offered that the 650 trials shows the dedication of the team to producing high quality, valid results. The reviewer suggested including a dimensional tolerance study to help increase the manufacturability of the process.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer commented that the supply chain is included in the project.

Reviewer 2:
The reviewer commented that it is all internal to FCA and would have preferred if others had joined the project.

Reviewer 3:
The reviewer commented that the cross functional team, including a coating finisher and a coating supplier, indicates the collaborative nature of the project team.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer commented that corrosion is indeed very important and the reviewer hoped that the team will continue to work with the same care and diligence.

Reviewer 2:
The reviewer commented that the proposed work addresses all the areas of the technical development plan.

Reviewer 3:
The reviewer summarized that the future plan includes corrosion testing and other shapes and suggested it may be interesting to see whether this technique can be extended to other cast alloys including Al. The reviewer also surmised that the investigation can extend to use free standing protrusions for other wrought materials.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer commented that joining and corrosion of mixed material joints is a key enabler for lightweight vehicle designs.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer commented that resources would be insufficient if another carmaker had been involved.

Acronyms and Abbreviations

3-D	Three Dimensional
Al	Aluminum
ARL	Army Research Lab
BIW	Body in white
CF	Carbon fiber
CFC	Carbon fiber composite
CO2	Carbon Dioxide
Cu	Copper
DOE	Department of Energy
FBCC	Front bumper and crush can
Fe	Iron
FOA	Funding Opportunity Announcement
FY	Fiscal Year
GATE	Graduate Automotive Technology Education
H2	Hydrogen
ICME	Integrated Computational Material Engineering
LCA	Life-cycle analysis
LCCF	Low-Cost Carbon Fibers
Mg	Magnesium
MMV	Multi-material vehicle
Nd	Neodymium
NF	Nanofiber
Ni	Nickel
NSF	National Science Foundation
OEM	Original Equipment Manufacturer
ORNL	Oak Ridge National Laboratory
PI	Principal Investigator

PNNL	Pacific Northwest National Laboratory
RE	Rare earth
TARDEC	Tank Automotive Research Development and Engineering Center
USAMP	United States Automotive Materials Partnership
VTO	Vehicle Technologies Office

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7. Propulsion Materials

Advanced materials are essential for boosting the fuel economy of modern automobiles while maintaining safety and performance.

Propulsion materials enable higher efficiencies in propulsion systems of all types. For example, many combustion engine components require advanced propulsion materials so they can withstand the high pressures and temperatures of high-efficiency combustion regimes. Similarly, novel propulsion materials may be able to replace the current expensive materials in electric motors and drivetrain components, thus lowering the cost of electric-drive vehicles.

Using lightweight components and high-efficiency engines enabled by advanced materials in one quarter of the U.S. fleet could save more than 5 billion gallons of fuel annually by 2030.

The U.S. Department of Energy (DOE) Vehicle Technologies Office (VTO) collaborates with industry to improve materials that will increase vehicle efficiency while meeting consumer and industry expectations. It does this through work on both Lightweight Materials and Propulsion Materials. In the case of Propulsion Materials, VTO works closely with other VTO subprogram technology areas to identify and meet requirements for materials needed to develop cost-effective, highly efficient, and environmentally friendly next-generation heavy and light duty powertrains.

Research and development is done in collaboration with industry, national laboratories, and universities. The VTO contributes to the Materials Genome Initiative, a federal interagency effort to support Integrated Computational Materials Engineering. It also works through government/industry partnerships:

- The U.S. DRIVE Partnership focusing on light-duty vehicles
- The 21st Century Truck Partnership, focusing on heavy-duty vehicles
- The US Automotive Materials Partnership (USAMP).

The Propulsion Materials subprogram's major R&D goal is to develop high performance cost-effective materials that solve key challenges that currently limit the performance of propulsion systems (high-efficiency engines and electric drive, and compatibility with alternative fuels).

Subprogram Feedback

DOE received feedback on the overall technical subprogram areas presented during the 2015 Annual Merit Review (AMR). Each subprogram technical session was introduced with a presentation that provided an overview of subprogram goals and recent progress, followed by a series of detailed topic area project presentations.

The reviewers for a given subprogram area responded to a series of specific questions regarding the breadth, depth, and appropriateness of that DOE VTO subprogram's activities. The subprogram overview questions are listed below, and it should be noted that no scoring metrics were applied. These questions were used for all VTO subprogram overviews.

Question 1. Was the program area, including overall strategy, adequately covered?

Question 2. Is there an appropriate balance between near- mid- and long-term research and development?

Question 3. Were important issues and challenges identified?

Question 4. Are plans identified for addressing issues and challenges?

Question 5. Was progress clearly benchmarked against the previous year?

Question 6. Are the projects in this technology area addressing the broad problems and barriers that the Vehicle Technologies Office (VTO) is trying to solve?

Question 7. Does the program area appear to be focused, well-managed, and effective in addressing VTO's needs?

Question 8. What are the key strengths and weaknesses of the projects in this program area? Do any of the projects stand out on either end of the spectrum?

Question 9. Do these projects represent novel and/or innovative ways to approach these barriers as appropriate?

Question 10. Has the program area engaged appropriate partners?

Question 11. Is the program area collaborating with them effectively?

Question 12. Are there any gaps in the portfolio for this technology area?

Question 13. Are there topics that are not being adequately addressed?

Question 14. Are there other areas that this program area should consider funding to meet overall programmatic goals?

Question 15. Can you recommend new ways to approach the barriers addressed by this program area?

Question 16. Are there any other suggestions to improve the effectiveness of this program area?

Responses to the subprogram overview questions are summarized in the following pages. Individual reviewer comments for each question are identified under the heading Reviewer 1, Reviewer 2, etc. Note that reviewer comments may be ordered differently; for example, for each specific subprogram overview presentation, the reviewer identified as Reviewer 1 in the first question may not be Reviewer 1 in the second question, etc.

Subprogram Overview Comments: Will Joost (U.S. Department of Energy) - lm000

Question 1: Was the program area, including overall strategy, adequately covered?

Reviewer 1:

The reviewer said that the overall strategy for materials was well identified, particularly the Materials Technology Gap Priorities slide. However, the reviewer did not see propulsion represented in this slide, only the lightweight materials. The reviewer recommended a similar prioritization be shown for the propulsion technologies, and also recommends showing a clearer breakdown of which items are higher priority.

Question 2: Is there an appropriate balance between near- mid- and long-term research and development?

Reviewer 1:

The reviewer said that the presentation gave a good overview of the challenges that the materials team is facing and some of the research and development, but delegated much of the explanation of the research and development to the individual project presentations. The reviewer recommended that it would have been clearer showing how the projects are linked into stated project goals instead of a list of projects explaining what the projects are currently doing.

Question 3: Were important issues and challenges identified?

Reviewer 1:

The reviewer said that key challenges were explained and summarized well.

Question 4: Are plans identified for addressing issues and challenges?

Reviewer 1:

The reviewer said that the roadmap addresses many of the challenges and the plans to address them.

Question 5: Was progress clearly benchmarked against the previous year?

Reviewer 1:

The reviewer did not see a clear comparison to the previous year. The highlights shown gave some indication, but the few shown did not mirror the breadth of projects.

Question 6: Are the projects in this technology area addressing the broad problems and barriers that the Vehicle Technologies Office (VTO) is trying to solve?

Reviewer 1:

The reviewer said that the projects are addressing broad problems and barriers.

Question 7: Does the program area appear to be focused, well-managed, and effective in addressing VTO’s needs?

Reviewer 1:

The reviewer said that the program appears well focused and managed tactically, but the broader strategic goals and timeframe to accomplish the goals were not shared.

Question 8: What are the key strengths and weaknesses of the projects in this program area? Do any of the projects stand out on either end of the spectrum?

Reviewer 1:

The reviewer said that the overall plan, particularly for lightweight materials, seems to be an all of the above strategy. The reviewer expects that eventually there will be a drive to down-select some of the alloy categories, but the reviewer agrees that would be premature at this stage. The reviewer said that one strength of this program is that the projects under this program area appear to be high risk/high reward, and that one weakness is while both the lightweighting and propulsion sub-programs contain a computational or integrated computational modeling (ICME) approach, the projects seem to be separate, rather than integrated or weaved into existing programs.

Question 9: Do these projects represent novel and/or innovative ways to approach these barriers as appropriate?

Reviewer 1:

The reviewer said that there is insufficient information to evaluate if the approaches are novel or innovative.

Question 10: Has the program area engaged appropriate partners?

Reviewer 1:

The reviewer said that the program seems well-integrated into federally funded research centers, industrial and academic partners.

Question 11: Is the program area collaborating with them effectively?

Reviewer 1:

The reviewer said that the program has done a good job of facilitating interaction between these groups.

Question 12: Are there any gaps in the portfolio for this technology area?

Reviewer 1:

The reviewer sees a few gaps. The reviewer asked what materials beyond magnesium (Mg) and carbon fiber (CF) composite will be needed to reduce weight beyond 37%, and how are predictive models shared and/or translated from academic to industrial use.

Question 13: Are there topics that are not being adequately addressed?

Reviewer 1:

The reviewer said that it is difficult to assess if topics are not being adequately addressed. The program area is very broad, and there will always be tradeoffs on what can be accomplished with limited funding.

Question 14: Are there other areas that this program area should consider funding to meet overall programmatic goals?

Reviewer 1:

The reviewer pointed out that there are still a number of challenges in aluminum (Al) and steel that are unaddressed and sparsely represented in the projects, as well as materials for glazings and other car components that could be used to lightweight the vehicle.

Question 15: Can you recommend new ways to approach the barriers addressed by this program area?

Reviewer 1:

The reviewer said that overall, the program area seems well aligned to deal with many of the barriers.

Question 16: Are there any other suggestions to improve the effectiveness of this program area?

Reviewer 1:

The reviewer said that it is difficult to evaluate the effectiveness of the program area with the information provided.

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.

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Novel Manufacturing Technologies for High Power Induction and Permanent Magnet Electric Motors	Grant, Glenn (PNNL)	7-8	3.33	3.17	3.33	3.17	3.23
Materials Issues Associated with EGR Systems	Lance, Michael (ORNL)	7-11	3.00	3.17	3.33	3.00	3.13
High-Temperature Aluminum Alloys (Agreement ID:24034) Project ID:18518	Pitman, Stan (PNNL)	7-14	3.13	3.00	3.13	3.00	3.05
Tailored Materials for Improved Internal Combustion Engine Efficiency	Grant, Glenn (PNNL)	7-17	3.42	3.42	3.50	3.33	3.42
High-Temperature Materials for High-Efficiency Engines	Muralidharan, G. (ORNL)	7-22	3.10	3.10	2.70	3.20	3.06
Enabling Materials for High-Temperature Power Electronics (Agreement ID:26461) Project ID:18516	Wereszczak, Andrew (ORNL)	7-26	3.50	3.75	3.50	3.50	3.63

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Biofuel Impacts on Aftertreatment Devices (Agreement ID:26463) Project ID:18519	Lance, Michael (ORNL)	7-29	3.33	3.17	3.67	3.17	3.27
Applied Integrated Computational Materials Engineering for New Propulsion Materials	Finney, Charles (ORNL)	7-32	3.33	3.17	2.83	3.17	3.17
Development of Advanced High-Strength Cast Alloys for Heavy-Duty Engines	Huff, Rich (Caterpillar)	7-35	3.36	3.29	3.36	3.21	3.30
Integrated Computational Materials Engineering Guided Development of Advanced Cast Aluminum Alloys For Automotive Engine Applications	Li, Mei (Ford)	7-39	3.50	3.60	3.60	3.30	3.54
Computational Design and Development of a New, Lightweight Cast Alloy for Advanced Cylinder Heads in High-Efficiency, Light-Duty Engines FOA 648-3a	Walker, Mike (General Motors)	7-43	2.92	3.00	3.08	3.00	2.99

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
High-Performance Cast Aluminum Alloys for Next Generation Passenger Vehicle Engines 2012 FOA 648 Topic 3a	Shyam, Amit (ORNL)	7-47	3.25	3.00	3.08	2.92	3.06
Alloy Development for High-Performance Cast Crankshafts	Huff, Rich (Caterpillar)	7-51	3.36	3.07	3.29	3.14	3.18
Overall Average			**3.27**	**3.22**	**3.26**	**3.16**	**3.23**

Novel Manufacturing Technologies for High Power Induction and Permanent Magnet Electric Motors: Glenn Grant (Pacific Northwest National Laboratory) - pm004

Presenter

Glenn Grant, Pacific Northwest National Laboratory.

Reviewer Sample Size

A total of three reviewers evaluated this project.

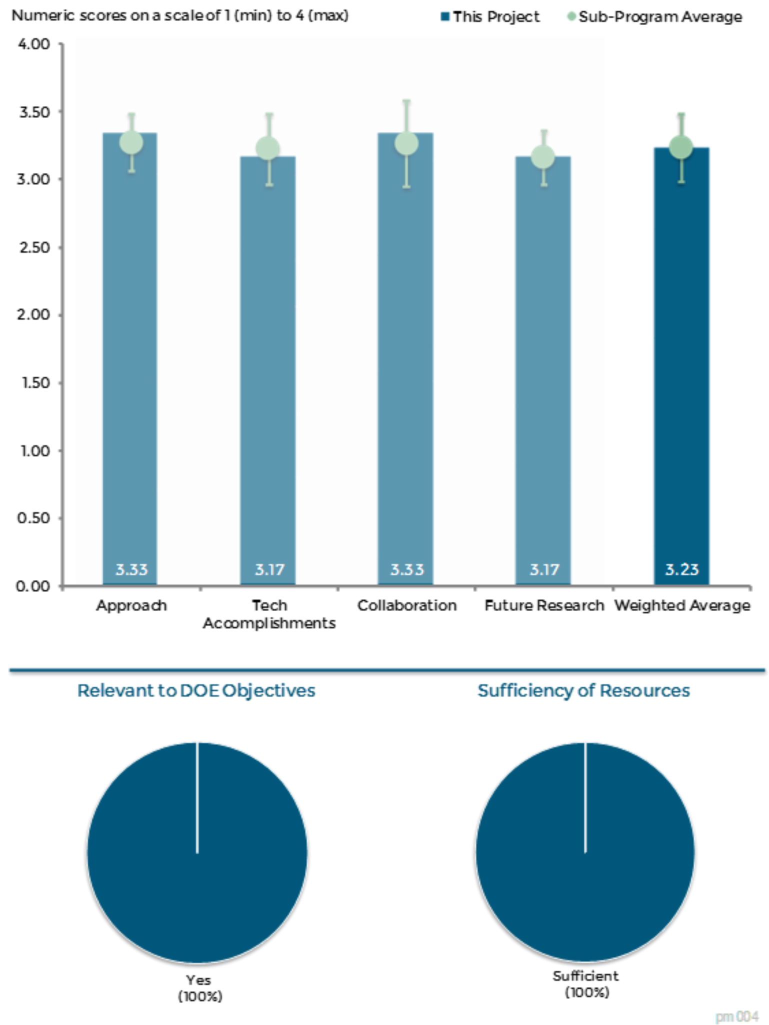


Figure 7-1 Novel Manufacturing Technologies for High Power Induction and Permanent Magnet Electric Motors: Glenn Grant (Pacific Northwest National Laboratory) – Propulsion Materials

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer believed the project appeared to be targeted to overcoming existing barriers to improved electric motors, particularly to ensure successful manufacturing. Likewise, the structure of the project was deemed focused on specific issues, with activities designed to make incremental progress toward goals. The reviewer noted that the project focus is not only on manufacturing processes, but also on development of related software and that the project also includes a few innovative approaches to resolving materials production issues.

Reviewer 2:

This reviewer praised the cooperative research & development agreement (CRADA) project as well designed, with the potential to reduce the cost of electric motors, thus enabling higher-efficiency propulsion. Terming the project high-value, the reviewer described it as primarily a manufacturing/tooling/fixturing effort, with little discussion of materials composition, structure or properties.

Reviewer 3:

In this reviewer's estimation, the work addresses a key opportunity for reducing the cost of electric motors – a significant barrier to consumer acceptance of electric vehicles. The team is working with lower-cost induction machines, and looking at the efficiency and cost aspects, which the reviewer deemed very important. The reviewer considered the team to be making good use of an existing, well-defined process previously funded by DOE VTO (i.e., friction stir welding) for a new application. This, the reviewer said, is a good repurposing of previously funded DOE work, expanding its reach. It is very important, the reviewer went on, to bridge the gap between research & development (R&D) and manufacturing, which is a goal of this project. The reviewer noted the project acknowledges the need to minimize waste of expensive copper, as a cost reduction effort.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

Most tasks appear on schedule, the reviewer said, noting that there had been a few challenges along the way. The reviewer observed that one area, namely shouldered tool assembly, had been delayed, and is currently scheduled for completion right before the end of the project. The project is still seeing a few issues (e.g., temperature increases during welding), the reviewer continued, but the principal investigator (PI) appears to feel the situation is now largely under control. The project did show successful development of friction taper plug welding as a solution to exit hole issues.

Reviewer 2:

In spite of the barriers and delays, the reviewer observed that progress appeared to have been made in controlling temperature and distortion and exit process. After almost four years, however, the reviewer believed it would have been better to see joining of an actual copper end cap, rather than the mockups. The reviewer also believed it was unclear why aluminum (Al) end caps were being attempted, since those can be overcast via a lower-cost process. Nor did the reviewer feel it had been made clear why there was no iterative plan for General Motors (GM) to test the four fully welded rotors and then come back to Pacific Northwest National Laboratory (PNNL) to further mitigate any potential deficiencies.

Reviewer 3:

Calling the temperature control achievement significant, the reviewer predicted it will be important for high-quality welds and said the team had used an interesting solution for this problem. Likewise, the team has achieved its milestone for temperature control, the reviewer said, and demonstrated the benefit of the applied solution. Noting the challenge posed by dealing with the exit hole left by the friction stir welding tool, the reviewer observed that the team has investigated several creative methods to plug exit holes, devoting a significant amount of work to addressing this challenge. The reviewer believed the team is thinking about the correct factors for the solution to accomplish this (low-cost, manufacturability), and have a realistic view of the opportunities with the dissimilar bonding effort (Al/copper), given the difficulties involved. Copper-copper weld seems to be of greater importance, the reviewer said, with success there seeming to be the most critical.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted that the project is proceeding under a CRADA with GM and includes biweekly project conference calls with team members. The reviewer also observed that at the conclusion of the project, the technology will be transferred to GM, which will perform the testing.

Reviewer 2:

There appeared to be good collaboration with GM, in the opinion of the reviewer, as evidenced by $1.3 million in cost share. Even better, in this reviewer’s view, would have been to have had testing of the fully welded rotors prior to the end of the project, in order to allow feedback to the processing experiments, before weld parameters were transferred to the CRADA partner.

Reviewer 3:

Noting that the team is partnering with GM, a key electric drive original equipment manufacturer (OEM), the reviewer predicted that this will assist in eventual commercialization of the technology. Collaboration with GM for testing of final rotors, the reviewer observed, also takes advantage of their expertise. Close collaboration and communication with OEM partner seems appropriate, the reviewer concluded.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer pointed out that the project team are still trying to resolve issues with the dissimilar material rotor and having difficulties with the geometry of the joint to be welded. It was unclear to the reviewer that a solution will be found. However, the reviewer also observed that the PI (principal investigator) said a solution for this pathway was not critical in view of other solutions that have been developed under this project. The reviewer noted that remaining efforts are focused on the shouldered tool assembly, adding that a lot remains to be completed before the project ends.

Reviewer 2:

Proposed work for remainder of the fiscal year appeared to this reviewer to be reasonable, given the project's completion timeframe. Technology transfer, the reviewer said, is the key aspect of the future work - transferring results with minimal need for additional refinement at GM.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The project is focused on decreasing the cost and weight while increasing efficiency and durability of electric motors, the reviewer said, to enable greater penetration of electric vehicles.

Reviewer 2:

The project does address broader goals for petroleum reduction through lower-cost manufacturing of electric vehicle (EV) components which, the reviewer said, will increase consumer acceptance of these vehicles and achieve petroleum reduction.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The resources appear sufficient to complete the project this fiscal year, in the reviewer's opinion.

Reviewer 2:

The reviewer did not comment beyond terming resources sufficient.

Reviewer 3:

The reviewer commented that PNNL has achieved the goals set forth for them using the resources given. The project team has made good use of cost share from GM to create resource sufficiency and ensure the commercial partner has made a commitment to the technology.

Materials Issues Associated with EGR Systems: Michael Lance (Oak Ridge National Laboratory) - pm009

Presenter

Michael Lance, Oak Ridge National Laboratory.

Reviewer Sample Size

A total of three reviewers evaluated this project.

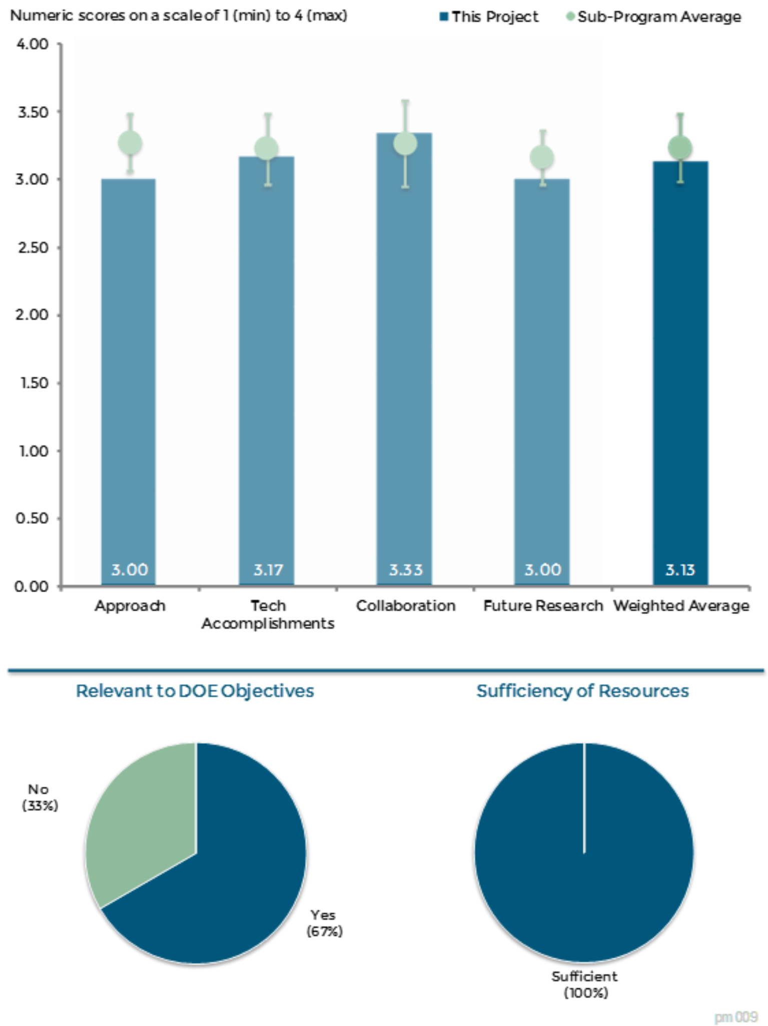


Figure 7-2 Materials Issues Associated with EGR Systems: Michael Lance (Oak Ridge National Laboratory) – Propulsion Materials

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer wondered if there is a plan to conduct tests to quantify the effects of potassium (K) on exhaust gas catalyst degradation and system performance. The presentation indicated that K may be bad actor, the reviewer noted, and asked if this will be validated in the next two years. Improved engine and validated fuel doping levels, the reviewer said, indicate proper case has been taken to ensure realistic exhaust gas conditions are achieved in accelerated engine testing, which seemed to the reviewer like the best approach to simulate and test the effects of aging on these materials.

Reviewer 2:

The reviewer speculated that the project's dependence on field samples with limited exploration of the impacts of engine operating factors may be a limitation on understanding all aspects of this phenomenon. The focus, the reviewer said, seems to be on understanding the deposition and removal processes within existing cooler designs rather than a broader, total, system-level approach that could consider other engine design changes to solve this problem.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

Though praising this as thorough characterization work, the reviewer was unsure if the actual conclusions were based on the objectives or if alternatives or improvements are being identified.

Reviewer 2:

The work accomplished has been well done, the reviewer said, but discerned no plan with an end goal. What will terminate this project, the reviewer asked.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The project displays excellent collaboration, the reviewer offered, with industry and government and professional agencies providing oversight and support of entire industry.

Reviewer 2:

In the opinion of this reviewer, the collaboration with Modine seemed closer than the interactions with the various engine companies, other than possibly with John Deere. Nor was it clear to this reviewer how the other engine companies are engaged other than in providing some field parts.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer urged that the focus be placed on sodium (Na) and asked if more work could be done on phosphorus (P) in the remaining two years. Also, the reviewer wondered if the various elements studied could be prioritized based on their impact on the various catalyst materials.

Reviewer 2:

It's good, the reviewer said, to see a design-of-experiments-driven investigation planned at Deere. However, the reviewer noted, the work to increase the water content of the exhaust gas recirculation (EGR) gas above that already present is not accompanied by a plan for actually doing this in a vehicle.

Reviewer 3:

According to this reviewer, the difference between model results and experimental data is ascribed to the grove on the uphill side of the wave structure. However, it was unclear if other parameters are evaluated simultaneously with this one or if there is any possibility that the grove is the sole and right contributor. The reviewer also questioned how the deposit thickness profile shown across the wave structure (center is thicker than edge) was explained. Finally, the reviewer suggested examining other geometric parameters, turbulence behavior and temperature gradient/dynamic change with time and along the structure.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

While unsure of the impact of this project on DOE petroleum displacement goals, the reviewer agreed that finding a solution to this problem would benefit the industry. However, if this remains a major fuel economy or warranty problem for the industry, the reviewer went on, the industry is likely to design around this problem and has several design options, including using a more expensive low-pressure EGR loop sourced from downstream of the diesel oxidation catalyst (DOC).

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

In the estimation of this reviewer, there appeared to be significant support provided through collaborations.

Reviewer 2:

The project embodies good tools, creatively used, the reviewer said.

High-Temperature Aluminum Alloys (Agreement ID:24034) Project ID:18518: Stan Pitman (Pacific Northwest National Laboratory) - pm044

Presenter

Nicole Overman, Pacific Northwest National Laboratory.

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

Noting that the main focus of the work was evaluating the properties and microstructure of a consolidated flake Al-based alloy, the reviewer considered that this general focus was adhered to with an adequate presentation of the technical benefits.

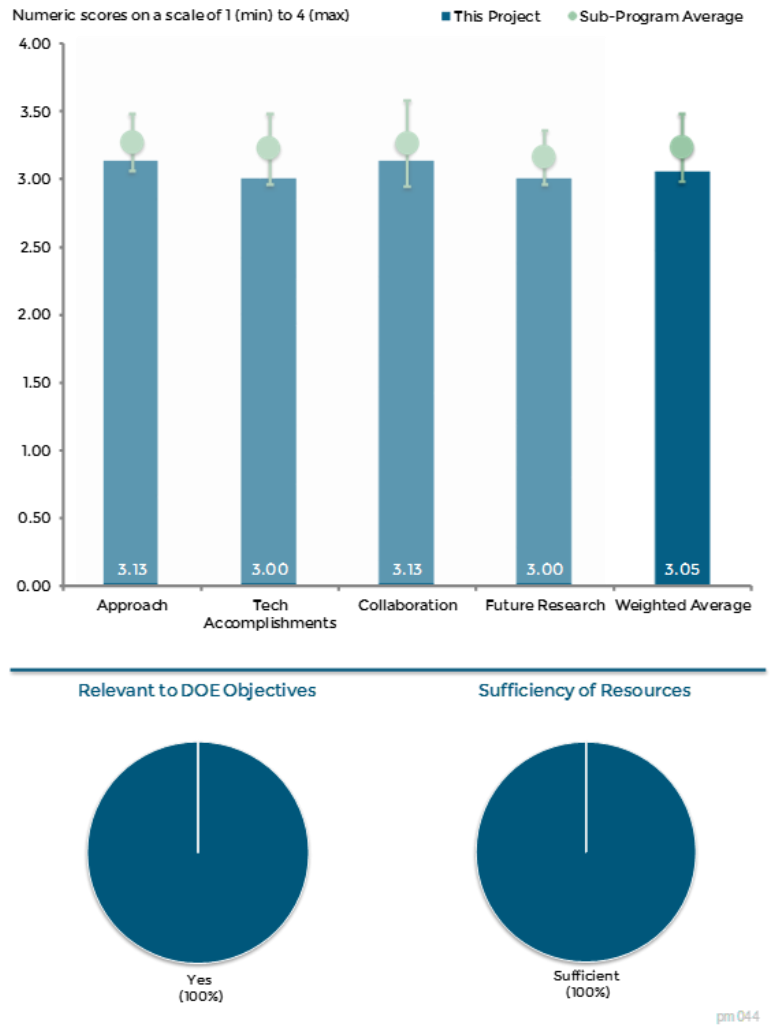


Figure 7-3 High-Temperature Aluminum Alloys (Agreement ID:24034) Project ID:18518: Stan Pitman (Pacific Northwest National Laboratory) – Propulsion Materials

Reviewer 2:

Improved materials are needed to increase engine performance and efficiency, the reviewer said, and this project appears to be specifically targeted at solving key materials barriers, namely improved-performance Al alloys, while maintaining reasonable manufacturing processes and cost. Existing high-performance Al alloys, the reviewer observed, have very high manufacturing requirements.

Reviewer 3:

The approach appears to this reviewer to have overcome the barriers identified in the project. This project is essentially complete with the exception of some final fatigue testing, evaluation, cost analysis, and project reporting/publication, the reviewer said, adding that it appeared that ultimate tensile strength (UTS) targets using rapidly solidified (RS) flake material have been met.

Reviewer 4:

The approach to developing new, higher-temperature, higher-strength Al materials was innovative, in this reviewer’s opinion. Likewise, the reviewer found it encouraging to see the process scaled up to 500-pound batches with good tensile properties. However, the reviewer added, it is unfortunate that fatigue testing has been delayed until the final two quarters of the project. The reviewer deemed this lack of knowledge of processing parameters a significant barrier, as was clearly explained by the presenter, and an unfortunate flaw resulting from limited resource availability.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The overall objective of this project, developing Al alloys with enhanced high-energy temperature strength, appears to have been met or exceeded, the reviewer said, this objective clearly fitting within DOE's goals of weight reduction and fuel efficiency. Additional work, to be performed this year, will provide key knowledge on material performance (fatigue testing) and ultimate processing/production costs, the reviewer concluded.

Reviewer 2:

Noting that there had been some issues with completing milestones on the original schedule, the reviewer nonetheless said the project team appeared to be largely back on track, albeit with a lot left to do. The project team has almost reached the ultimate tensile strength target defined by Cummins, the reviewer pointed out, but did run into a barrier with the proprietary materials processing which called for greater microstructure analysis and testing/evaluation.

Reviewer 3:

Although progress was good, the reviewer said, a lot of time and energy had to be expended on characterizing materials to understand the effects of unknown processing parameters. The reviewer acknowledged the considerable challenge of making best progress without processing knowledge, but said the investigators seem to have made progress nonetheless. The phase decomposition seen during processing suggested to this reviewer that the material might have stability issues over longer times at high temperatures. In addition to the 300°C tensile testing, in the reviewer’s opinion, it would have been valuable to include room temperature or elevated temperature tensile testing after extended periods at 300°C (e.g., 100, 200, and/or 500 hours) to evaluate microstructure and properties stability. Fatigue testing would, to this reviewer, also seem to be crucial at an earlier stage of the project. Nonetheless, the reviewer welcomed its t inclusion in future work for fiscal year (FY) 2015. This project, the reviewer concluded, seems to have unique potential if the material is stable at 300°C, and if the economics are favorable.

Reviewer 4:

The reviewer deemed this a very interesting concept. The alloy composition was described as PNNL-developed, but the reviewer heard no substantial explanation of why it was chosen.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer discerned close coordination in this project among the team members, including Transmet (for materials), Cummins (for ultimate application as well as testing and analysis), and the University of California-Riverside (technical advisor, added this year to strengthen the team). The partners are providing cost-share equal to the federal funding, the reviewer noted in closing.

Reviewer 2:

Coordination with Transmet seemed fruitful to the reviewer, who noted some apparent attempt to reverse engineer Transmet's process with regard to cooling rate. This was not presented as intellectual property (IP), the reviewer said, just a lack of sharing of information.

Reviewer 3:

Cummins and partners provided $1.15 million in cost-share, which the reviewer found impressive, but was unclear on the specific role of Cummins in the description of approach or results.

Reviewer 4:

The collaboration with Cummins via a CRADA worked well, in this reviewer’s estimation. It was unclear to the reviewer, on the other hand, why an agreement was not made with Transmet, although the reviewer noted that a lack of knowledge of processing conditions controlled by Transmet impacted the understanding of strength reductions. The reviewer was left wondering if the conclusions regarding phase decomposition related to processing were confirmed by Transmet.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer noted that the project is nearing completion and predicted that the relative newness of the technique means further development of the process will certainly be needed before production can be scaled up. Nevertheless, the reviewer said, the concept offers interesting potential.

Reviewer 2:

The project is scheduled to be completed at end of FY 2015, the reviewer observed, and while there is still much left to do, much has already been started since the presentation was prepared. The presenter (whom the reviewer noted was not the project lead) seemed to the reviewer to be confident that the work will be completed on time. An earlier subcontractor issue with equipment caused a 6-12 month delay, the reviewer said.

Reviewer 3:

Noting that the project was at or near its end, the reviewer further noted that no future work beyond FY 2015 was proposed and that work for the remainder of FY 2015 was mostly wrap-up.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This project, the reviewer said, is aimed at improved materials necessary to increase the performance and efficiency of engines.

Reviewer 2:

The reviewer deemed this project to support DOE’s overarching goal, with a caveat, namely, that while the ability to produce high-performance Al alloys certainly meets the DOE lightweight/strength objectives, the process can hardly be considered low-cost, high-volume, because it can only produce very limited sizes and geometries and requires a number of controlled consolidation steps in production.

Reviewer 3:

The project provides knowledge on the potential and value of using RS process to improve the high-temperature tensile strength of Al, the reviewer said, but its contribution to the open literature may be compromised by lack of processing knowledge from partner.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

Tasks appeared to the reviewer to have been successfully accomplished with the resources provided.

Reviewer 2:

The reviewer observed that the project is completing.

Reviewer 3:

The presenter did not indicate any concerns about resources, the reviewer said, adding that the project is existing now on carry-over funding from previous fiscal years, likely due to delays in schedule.

Tailored Materials for Improved Internal Combustion Engine Efficiency: Glenn Grant (Pacific Northwest National Laboratory) - pm048

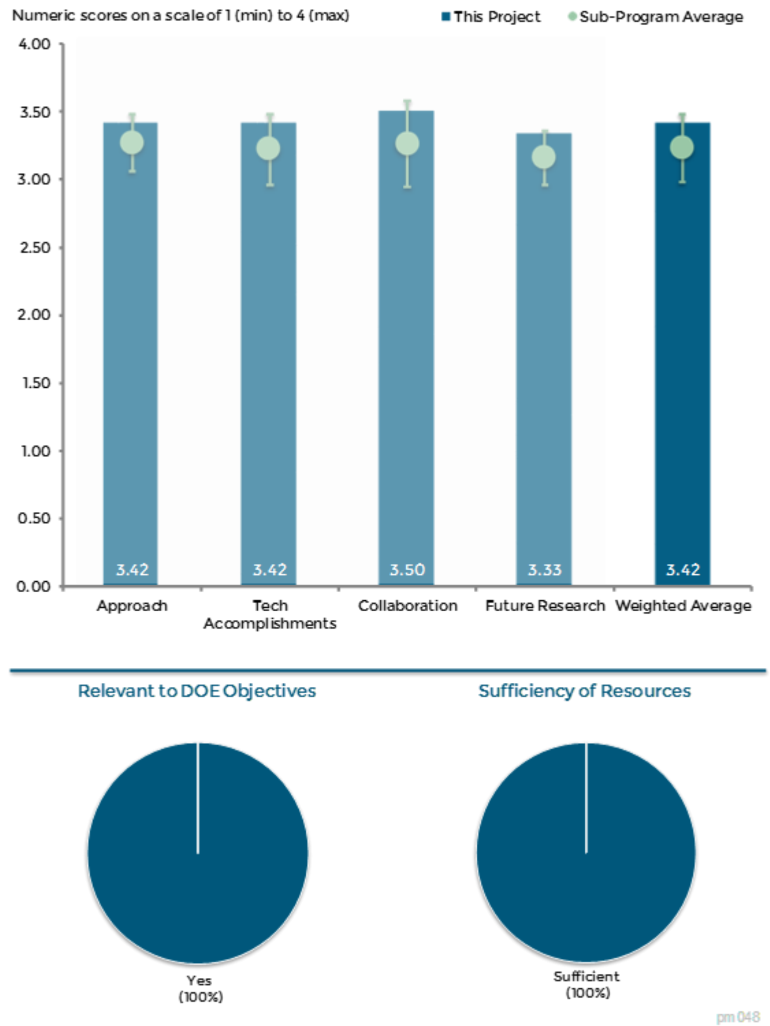


Figure 7-4 Tailored Materials for Improved Internal Combustion Engine Efficiency: Glenn Grant (Pacific Northwest National Laboratory) – Propulsion Materials

Presenter

Glenn Grant, Pacific Northwest National Laboratory.

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer considered the approach to be both interesting and novel. The concept of a tailored local microstructure in a cast component, the reviewer said, lends itself to a number of potential improvements in end-use performance. The properties being evaluated and the reasoning behind the research path the reviewer found to be very well presented. The reviewer suggested that from a process cost standpoint, proving the utility of the process in a regular production cycle may be a large barrier, but said demonstrating the feasibility of dedicated robotics seemed to address this issue.

Reviewer 2:

The reviewer considered the idea of demonstrating this on the oil hole region very interesting. It seemed to this reviewer that all relevant considerations had been included for the completion of the work. The time is short, the reviewer noted, but it appeared the project is close to completion.

Reviewer 3:

This project is nearly complete, the reviewer noted, the team having explored and developed the FSP for fatigue life enhancement in an Al alloy and a steel alloy. The team has demonstrated the potential improvements in fatigue life at high temperature and the potential benefit of localized FSP on a crankshaft surrogate, the reviewer observed.

Reviewer 4:

The project seemed well-designed to the reviewer and with potential to enable cast materials to have the fatigue life of forged components and thus lower cost. The ability to locally improve fatigue resistance of surface features that concentrate stress would be of significant value, in the reviewer's opinion, and evaluating both Al and micro-alloyed steel is the right approach. It might also be of interest, the reviewer speculated, to evaluate cast irons and determine what happens with the larger graphitic particles where a surface is exposed to friction stir processing. The reviewer pointed to the lack of fatigue testing of Al specimens with friction stir-modified surfaces, instead of mini specimens from the modified region as a weakness of the project.

Reviewer 5:

Controlling the grain size of surface and near-surface modified regions to improve high peak pressure and cycle life by varying well-known parameters appeared to this reviewer to be well thought-out. However, testing conditions, especially temperature, did not appear to this reviewer to display the same level of thoughtfulness. A more systematic approach to determine the appropriate temperature range to probe, the reviewer asserted, must be used to obtain results that accurately represent in-use performance.

Reviewer 6:

The reviewer summarized the approach as examining the existing alloy base and modifying the material microstructure to obtain improved performance parameters using friction stir processing (FSP) to modify surface and near-surface microstructures. The reviewer said the project had cost-effectively used coupons to test and modify conventional materials, noting that sufficient adjustments were available to fine-tune the microstructure by using a variety of knobs. All activities are focused on achieving improved processing to reduce the effects of fatigue on the material, the reviewer concluded.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The team has exceeded their goals for fatigue performance with Al and established a base for exploring the fatigue effects of different microstructures achievable with FSP, the reviewer said, and have also demonstrated positive results on wrought steel.

Reviewer 2:

Fatigue studies seemed complete enough, in this reviewer's view, to conclude the improvement of properties suggested.

Reviewer 3:

The project has identified an excellent application of FSP processing, the reviewer said, namely, drilled holes can be strengthened significantly if FSP treatment is applied. Manufacturing challenges remain for fillet development and the integration of newer, higher-performance materials, the reviewer noted. Steel tooling costs, while high, are not cost-prohibitive, the reviewer went on, adding that tooling could be embedded in the manufacturing process. The reviewer observed that FSP can take steel to a wrought form and porosity problems can also solved using FSP, making it appear a good approach to solving material failures occurring in the weakest link.

Reviewer 4:

Correlations of microstructures and properties provide clear evidence, the reviewer said, of the benefits of the proposed approach to tailoring microstructures. The electronic backscatter diffraction analysis, although well done in the reviewer's opinion, is probably inadequate for delving more fully into the local mechanisms. More in-depth analysis at transmission electron microscope (TEM)-level length scales would, the reviewer speculated, likely provide information critical to the observed fatigue response and may be an opportunity for future work.

Reviewer 5:

The identification of failure modes related to machining journal oil ports is significant and appropriate for improving a manufacturing process, the reviewer asserted, but, as the reviewer noted in the Approach section, careful selection of temperature conditions does not appear to have been addressed systematically. Beginning with an unrealistically low temperature for testing, the reviewer said, delayed results that should have been obtained under more realistic conditions. Likewise, the reviewer added, a second round of testing at 200°C did not appear to have been sufficient and 300°C is now planned. The reviewer noted that the investigators do not know where the break point of temperature versus cycle life will occur. Also, the reviewer said, thermal shock effects should be included in this analysis to simulate in-use conditions.

Reviewer 6:

Technical accomplishments were good, in the reviewer's estimation. The demonstrated improvements in fatigue life indicate promise, the reviewer said, although the geometric constraints of the process limit its application. However, for localized regions - such as those where holes have to be drilled, the process offers an intriguing option to reduce related stresses, the reviewer said, adding that it would have been good to see fatigue life results on Al specimens whose surface had been modified, rather than mini-specimens taken from only the friction stir-modified region. It was unclear to this reviewer why the mini specimens were used. The reviewer also noted that for the Al materials, the effect appeared to lessen at temperatures above 150°C, which the reviewer predicted will be a concern for the targeted components (heads, blocks). The reviewer found it curious that the finer-grained structure showed better fatigue life at the higher temperatures, as the presenter noted, and anticipated such a trend would not continue at 250°C for Al. The ability to reduce notch effects was of particular value, the reviewer said and urged it be further explored in an actual cast steel structure.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer praised the team for presenting a very thorough scientific and practical approach when pinpointing specific benefits to the internal combustion engine (ICE) cycle, such as work on actual crankshafts following coupon-level observations. This, the reviewer said, is testament to a good collaborative effort that includes elements of industry, academia and the national laboratory partners.

Reviewer 2:

Partnering with an OEM such as GM on this project is critical, in the opinion of this reviewer, because an OEM partner can provide essential feedback necessary to keep the project relevant to their production processes.

Reviewer 3:

The project has an excellent level of cost share (50/50) from GM, even without a CRADA, the reviewer said, which indicates an area of activity of significant interest to the industry partner.

Reviewer 4:

GM's participation on delivering component pieces to validate the studies will be useful and shows good collaboration, in the opinion of the reviewer.

Reviewer 5:

The reviewer termed industry (GM) coordination with the academic partner North Texas University (UNT) adequate for the size of the project.

Reviewer 6:

The reviewer foresaw collaboration and follow-on work with GM leading to a further understanding of the FSP process, how it can impact microstructure and how it may best be applied in industry. It was unclear to this reviewer, however, what has come out of the creep fatigue work performed by UNT.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

Noting that the program is completing and presently on carryover funds, the reviewer emphasized that the good rating offered was not indicative of any real shortcomings.

Reviewer 2:

The two primary future areas of research to further understand the benefits of controlling grain size are appropriate and should be explored, in this reviewer's opinion.

Reviewer 3:

The question of the material condition after processing through heat treatment and in hard-to- reach areas seemed appropriate to this reviewer.

Reviewer 4:

The reviewer recommended the project continue to focus efforts, if appropriate, on engine materials that fail most frequently, adding that quenching and other material hardening approaches should be compared to FSP where appropriate.

Reviewer 5:

In the estimation of the reviewer, ongoing collaboration with GM for three-dimensional (3D) development, part fabrication, component testing and commercial development provide a good path forward.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

Higher-performance components allow operating conditions beneficial to overall efficiency, the reviewer noted, adding that this program targets several specific areas for improvement and leaves the work open to additional applications.

Reviewer 2:

Improving the durability of OEM powertrains to 150,000 miles requires this type of research to lower the cost of providing the required durability, the reviewer said.

Reviewer 3:

Improving the life of rotating components should lead to innovative applications with improved efficiency, in the view of this reviewer.

Reviewer 4:

Higher-performer engine materials lead to engines that perform at higher temperatures, in turn leading to higher-efficiency engines, the reviewer pointed out.

Reviewer 5:

Localized strengthening of material in critical regions of components may yield positive results in weight reduction and performance, the reviewer said, thus leading to improved efficiency.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
This project has sufficient resources to accomplish the stated goals, the reviewer said, but additional future resources may be needed to further understand how the surface modifications will be impacted by temperature.

Reviewer 2:
Noting that the project is nearing completion, the reviewer said no shortcomings were identified.

Reviewer 3:
Good use was made of in-kind contributions from GM, in this reviewer’s opinion.

Reviewer 4:
To this reviewer, it seemed this project will be a race to the finish, but the reviewer expressed the belief the team had the needed resources to complete it.

Reviewer 5:
Resources appear sufficient for this effort, the reviewer said.

Reviewer 6:
Project has been essentially completed using resources available throughout its life, the reviewer observed.

High-Temperature Materials for High-Efficiency Engines: G. Muralidharan (Oak Ridge National Laboratory) - pm053

Presenter

G. Muralidharan, Oak Ridge National Laboratory.

Reviewer Sample Size

A total of five reviewers evaluated this project.

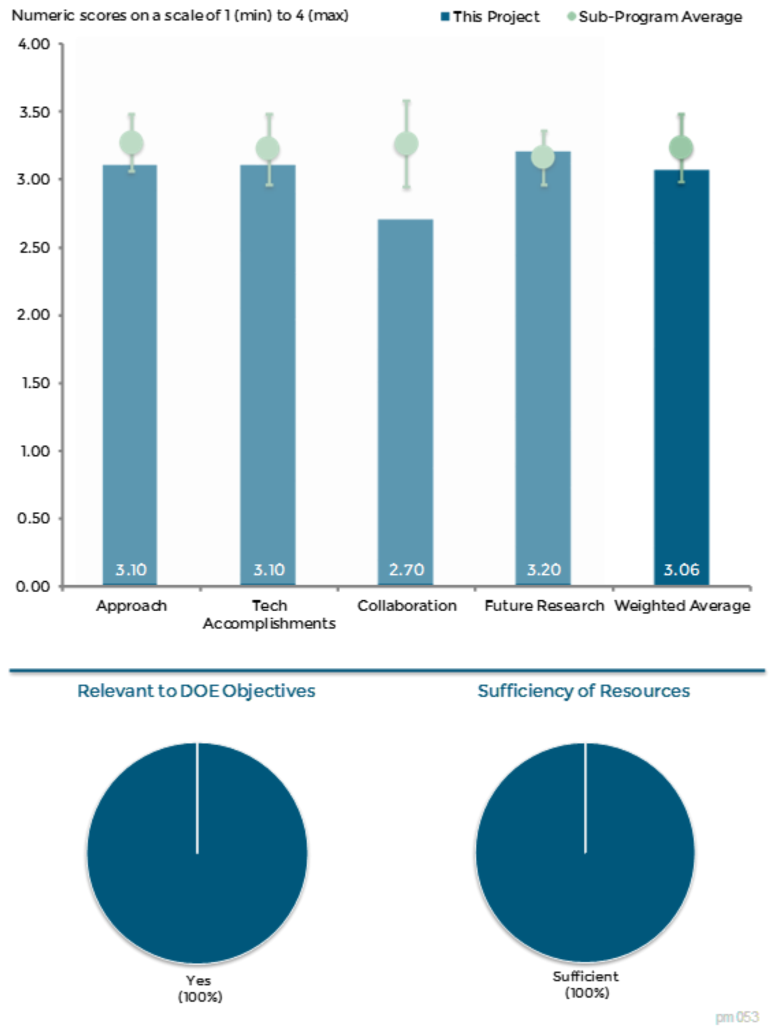


Figure 7-5 High-Temperature Materials for High-Efficiency Engines: G. Muralidharan (Oak Ridge National Laboratory) – Propulsion Materials

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

Nickel-based metals are high-cost alloys, the reviewer observed, so alternatives are being developed using ICME techniques. Any new alloy must meet both performance properties and cost parameters and ICME is a good, low-cost and efficient approach to developing new, affordable materials, the reviewer said.

Reviewer 2:

The reviewer summarized the project objective as to use ICME principles to develop lower-cost materials with desirable properties, including high-temperature strength, oxidation resistance and improved fatigue properties, a key goal being the achievement of high cycle life while reducing costs by reducing use of nickel (Ni) and cobalt (Co). The reviewer deemed the approach (i.e., identify material properties, correlate properties with microstructural characteristics, identify compositions while aiming to reduce composition contribution from Ni) to be reasonable given the objective of developing cost-effective valve materials for high-temperature (950°C) applications.

Reviewer 3:

The reviewer deemed the simulation-based composition development certainly to be an acceptable approach and regarded the principal investigator (PI) as clearly knowledgeable in this area. The results to date, the reviewer noted, depend largely upon oxidation behavior via mass loss testing. There was little mechanistic information presented, the reviewer said, noting the PI's continued references to alloys undergoing higher levels of mass loss as fading away, which the reviewer found somewhat puzzling. Fading away how, the reviewer asked. By spallation, the reviewer presumed, requesting that more information be provided to clarify the evaluation and results.

Reviewer 4:

Noting that an integrated computational materials engineering (ICME) approach was cited at the beginning of the presentation, the reviewer nonetheless discerned little connection between the ICME results and the experimental findings. An outcome from this work, the reviewer opined, could be an assessment of where ICME tools worked and did not work to guide future research. Other than a JMatPro result at the beginning of the presentation, the reviewer also saw no connection made between the oxidation resistance or strength and any modeling results.

Reviewer 5:

To the reviewer, the approach looked reasonable. A more fundamental study was suggested by this reviewer to understand the tradeoffs among composition, oxidation status, its impact on alloy performance, and the aspects that will impact scale analysis.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The project is on track to complete in FY 2016, the reviewer said, having used an enabling technology (ICME) to cost-effectively and efficiently develop a solution. Several alloying elements, the reviewer observed, appear to weaken the alloys to a point where they cannot meet the performance parameters. The reviewer noted that the project team had developed higher-performing, lower-cost alloys (490-2 and 161-12M) based on lessons learned from oxidate alloys and that ICME had helped map the solution. Likewise, it was determined that alloying element additions must carefully balance oxidation resistance with high-temperature strength, the reviewer concluded.

Reviewer 2:

Progress has been good, in the reviewer's estimation, with the identification, design and development of two alloys manufactured by Carpenter. The Oak Ridge National Laboratory (ORNL) alloys appeared to show improved yield strength but not improved oxidation resistance, the reviewer said.

Reviewer 3:

Development of new potential alloys seemed to this reviewer to be making progress. The major focus, however, seemed to be on making low-cost alloys by reducing Ni content. The reviewer wondered, however, what factors other than the nickel-chromium levels and what elements other than iron and titanium, which were mentioned, are being added to this low-cost alloy. Refractory alloys or rare earths, the reviewer pointed out, are generally apt to make Ni seem cheap by comparison. The presentation lacked data necessary to establish the cost structure of the new materials.

Reviewer 4:

Noting that the prior year's emphasis was on oxidation resistance, the reviewer saw little progress having been made, except perhaps to achieve equal oxidation resistance in more expensive materials. This relationship, the reviewer said, could have been made clearer to the objective of the project - higher oxidation resistance at the same strength level, or lower cost for equivalent material, etc. The final objective was not obvious to this reviewer from the presentation or discussion.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer commented that it was unclear how the mentioned potential collaborators (i.e., Carpenter and Cummins) will contribute to the project.

Reviewer 2:

The reviewer noted that parties that had a potential stake in the research were identified, but had made no actual collaborative effort with regard to funding contributions; the DOE funding level being described as 100%. The PI provided some basis for in-kind contributions from Carpenter Tech, the reviewer conceded, but found it difficult to believe that any future program proposed with a similar cost-share breakdown would be deemed agreeable at the proposal review stage.

Reviewer 3:

Collaborations were mentioned with both Carpenter and Caterpillar, the reviewer said, adding that it would be nice to know there are applications, specific properties, lower cost, or something else they are interested in. The reviewer acknowledged that such information may be sensitive, but it is nonetheless related to the objective of the project and should be clarified.

Reviewer 4:

The reviewer saw only limited collaboration with partners, because most work is done at the laboratory due to the limited budget and requirement to use the ICME infrastructure at ORNL.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

Terming the PIs extremely knowledgeable in Ni-based alloys and associated development, the reviewer said this is not a ground-up type of R&D effort, as the established knowledge base is likely carried over from other industries and will find future applications outside of the VTO. At present, the reviewer continued, the proposed research aims to develop an alloy capable of satisfactory strength and oxidation-resistance levels at 950°C, the results of which have a milestone scheduled in June.

Reviewer 2:

Downselect and complete testing of most promising alloys candidates was stated by this reviewer.

Reviewer 3:

With the experiments run so far and their results, the reviewer said, there seems to be a direction to optimize alloy and concept. The reviewer called attention to the fact that this assessment was made based on the presented experimental results, as no ICME feedback was highlighted to assist the acceleration of alloy development.

Reviewer 4:

The reviewer discerned an emphasis on oxidation resistance for future work but said it was unclear how the design of new alloys for this purpose will be accomplished. The reviewer also viewed the path to achieving the oxidation resistance goals coupled with tensile strength as rather vague.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

Higher-temperature materials can be used in more efficient engines, the reviewer noted and said this project will help accomplish that objective.

Reviewer 2:

Higher-performing alloys will be used to produce higher-efficiency engines, the reviewer asserted.

Reviewer 3:
Improved high-temperature strength properties along with reduced oxidation problems and reduced cost are key components of the DOE objectives, this reviewer said.

Reviewer 4:
Calling the criticality of this type of work to vehicle technologies debatable, the reviewer nonetheless agreed that advanced Ni alloys are certainly of interest to the DOE mission.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
With material given by Carpenter and support of Caterpillar, this project seemed to the reviewer to be adequately funded.

Reviewer 2:
Funding appeared to the reviewer to be sufficient for the proposed scope of work.

Reviewer 3:
Based on the presentation and the confidence expressed by the PI, the resources seemed sufficient to this reviewer, who noted that testing had begun at 950°C, the upper bound stated in the project objective. However, funding levels seemed cloudy to the reviewer, as the project is 50% complete, having spent $330,000, and anticipating $190,000 in FY 2015, which the reviewer presumed was planned carryover into FY 2016.

Reviewer 4:
Acknowledging that it was at best a guess, the reviewer said the resources were sufficient, given the progress to date, the relatively low funding level and the remaining work.

Enabling Materials for High-Temperature Power Electronics (Agreement ID:26461) Project ID:18516: Andrew Wereszczak (Oak Ridge National Laboratory) - pm054

Presenter

Andrew Wereszczak, Oak Ridge National Laboratory.

Reviewer Sample Size

A total of two reviewers evaluated this project.

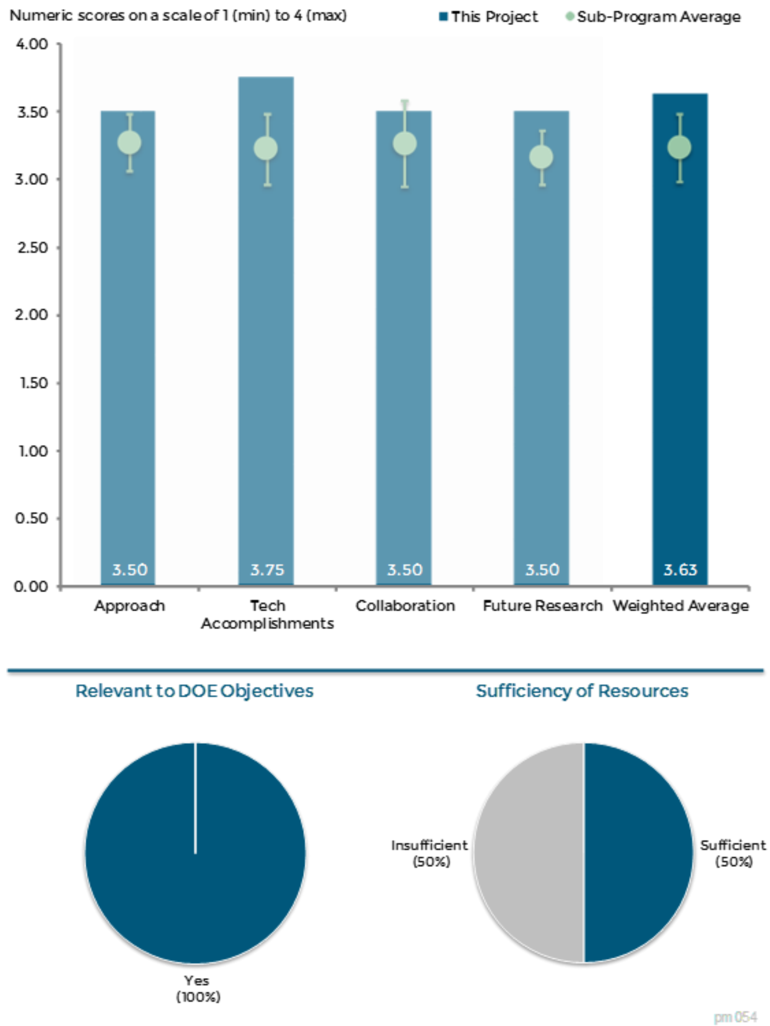


Figure 7-6 Enabling Materials for High-Temperature Power Electronics (Agreement ID:26461) Project ID:18516: Andrew Wereszczak (Oak Ridge National Laboratory) – Propulsion Materials

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This reviewer observed that the Propulsion Materials program is solving a difficult issue in power electronics, as 200°C-capable, low-cost materials would significantly decrease the cost of improved-efficiency power electronics. The reviewer lamented that funding limitations have restricted the investigation of a high-potential solution. If this solution is indeed of significant potential, the reviewer urged that DOE continue the effort fully to assess that option, because leveraging solutions from a parallel approach provides opportunity to solve more than one issue with a developed solution.

Reviewer 2:

Agreeing that this work addresses the overall Electric Drive Technologies (EDT) goals of reduced size, weight and cost, the reviewer believed the PI could have provided a more detailed explanation for the reasoning behind the 200°C target for power electronics (PE) components, as some audience members may not be clear on why that was established. The reviewer further described the work as combining materials and EDT expertise at ORNL and called the parallel efforts with PE and electric motor (EM) materials a reasonable approach, leveraging learnings between efforts. ORNL/ National Renewable Energy Laboratory (NREL) collaboration, the reviewer concluded, takes advantage of core capabilities at both labs.

Reviewer 3:

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer noted that the project team has achieved or is on track to achieve all key milestones for this 12-month period, except the dielectric work, and has provided a good technical reason for the no-go on that work. Moreover, the reviewer went on, the project team has made good use of model material to simulate semiconductors in an effective and low-cost way for residual stress work. Terming findings about differing coefficient of thermal expansion (CTE) materials and delamination important to determine parameters for use of sinterable silver as bonding agent, the reviewer pointed out that clear results were demonstrated through simple residual stress analysis for a complex problem.

Reviewer 2:

Solder failures were created in order to perform failure analysis, the reviewer noted, and reliability of interconnections will lead to optimized array sizes. This reviewer commented that using Invar as a surrogate is a good cost savings approach, because Invar has properties similar to those of silicon (Si) semiconductor material. The reviewer noted the onset of delamination in 10mm, 18mm, and 22mm diameter, but not in 10mm diameter. The reviewer also reported that the project team can effectively estimate the maximum allowable bonding size in bonding materials, which has been successfully completed). Further, periodic array of smaller sizes to avoid delamination was also observed.

Question 3: Comments on Collaboration and Coordination with other institutions:

Reviewer 1:

The reviewer praised the team for having a good and interesting list of collaborators, covering a wide spectrum of suppliers in this industry. The group covers key players in the supplier industry for the technologies being studied (sintering, polymers, etc.), the reviewer went on. There is also collaboration with OEMs, the reviewer noted, albeit indirectly through dissemination of results in the literature.

Reviewer 2:

The project embodies significant collaboration given its small budget, the reviewer said, observing that, in reality, the project entails two national laboratories (ORNL and NREL) working together.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

Proposed future work appeared reasonable to the reviewer, given the approach outlined (and the fact the project is just over half done), and includes important dissemination of results. The reviewer pronounced the project team on a path to successful completion with this future work.

Reviewer 2:

The reviewer noted that proposed future work includes placing crosscutting work in the public domain and disseminating results of this research. Shear strength has been the recent focus, the reviewer observed, and determining if thermal cycling reliability is negatively impacted will be investigated in future work.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

This work does support DOE petroleum displacement objectives, in the reviewer's view, because it will enable development of smaller and more cost-effective electric drive technology components. These, in turn, will improve the market acceptance of electric-drive vehicles and increase their petroleum displacement effects, the reviewer concluded.

High-temperature materials and high-temperature operation of EMs provide opportunity for higher-efficiency EMs.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer reiterated the estimation of resources appearing to be sufficient to accomplish the work outlined by the team.

Reviewer 2:

The reviewer noted that high-potential material is not being assessed because of funding limitations in the Propulsion Materials program.

Biofuel Impacts on Aftertreatment Devices (Agreement ID:26463) Project ID:18519: Michael Lance (Oak Ridge National Laboratory) - pm055

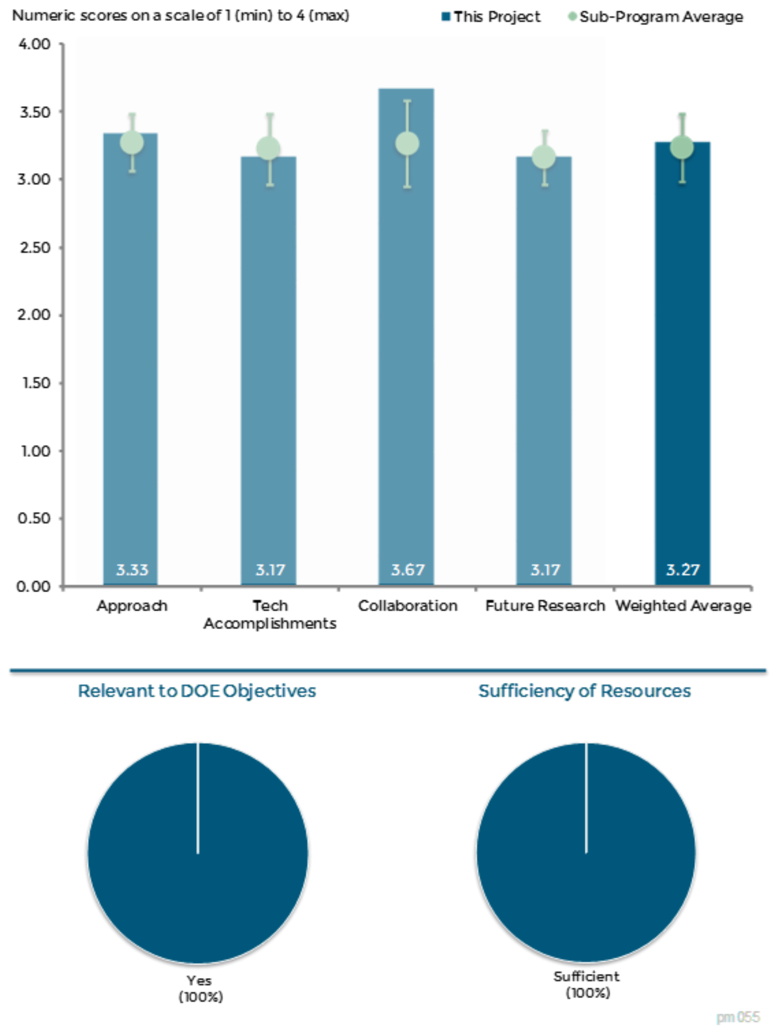


Figure 7-7 Biofuel Impacts on Aftertreatment Devices (Agreement ID:26463) Project ID:18519: Michael Lance (Oak Ridge National Laboratory) – Propulsion Materials

Presenter

Michael Lance, Oak Ridge National Laboratory.

Reviewer Sample Size

A total of three reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The project includes a well-designed evaluation plan, in the view of this reviewer, who expressed some concerns regarding the lack of replicate aftertreatment tests, while recognizing the cost impacts of replicate tests.

Reviewer 2:

The reviewer commended the presentation for its review of data and analysis which the reviewer called very good and comprehensive. The reviewer was, however, left with a question concerning the solubility of sodium sulfate and possibility of its migrating through the filter and causing downstream impacts. It would be better, this reviewer opined, to look at various engine duty cycles that better represent real operation to understand if real operation will result in different conclusion than the experimental work shows.

Reviewer 3:

The reviewer was unsure whether the computational fluid dynamics (CFD) considered particles, noting that velocities in front of the peaks would be highest and thus impinged with the greatest number of deposits. This, the reviewer said, would lead to the suspicion that this is where the deposit layer would be thickest. On the backside of the peaks, the reviewer went on, there would be a pressure drop, meaning less flow and thus less opportunity for deposit particles to contact the wall. The stickiness of the particles, in the reviewer's opinion, is not being correctly considered.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer did not see characterization of the thermo-physical properties of the deposits, which was a stated objective. High flow rates seemed to the reviewer to be a logical approach to reducing deposits by introducing enough shear at the boundary to overcome the stickiness of the particles or to erode the deposits like wind on a mountain peak. High flow rates combined with proper cooler design seemed to be the best approach to this reviewer, who further recommended avoiding peaks and associated pressure drops. The reviewer also noted that removing large build-ups at infrequent intervals could cause more damage downstream to other, more critical engine components.

Reviewer 2:

Deeming this really important work not only for the biodiesel industry but also as it applies to other fuel and oil additives, the reviewer cautioned that the impacts of Na on the complete system, rather than just the DOC, remains to be explained. Likewise, separating the impacts of Na and K, apart from the demonstrated impacts of P, also needs to be addressed, the reviewer said.

Reviewer 3:

The presented data show good, integrated analytical approach, the reviewer said, which seems to be well designed and fundamentally solid.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer observed that all industry leaders appear involved in at least an advisory role with many active participants.

Reviewer 2:

The project boasts a good team, in the view of this reviewer, with the Manufacturers of Emission Controls Association (MECA) balancing the National Biodiesel Board.

Reviewer 3:

The presentation showed, in the opinion of the reviewer, that this project has the support of industrial actors and can be used to solve industrial problems.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer regarded the issue as being clearly identified, the path forward outlined and capable of addressing the key questions.

Reviewer 2:

Proposed future work includes detailed experiments involving many variables that affect hydrocarbon properties, the reviewer noted. However, the CFD model will have to be improved to properly model and correlate deposit location and thickness. The reviewer further noted that cooler geometry is not one of the listed variables.

Reviewer 3:

The reviewer observed that the well-known influence of P on aftertreatment devices seems to cloud the assessment of Na and K in this work and was left wondering how this would be dealt with in future work.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
If biodiesel is to be accepted by the automotive industry, the reviewer said, it is important that fuel specifications are adequate to protect engines from unintended impacts of contaminants from the biodiesel process. This work, in the reviewer's opinion, is an important contribution to ensuring appropriate specifications that balance manufacturing costs and vehicle protection.

Reviewer 2:
This work is emission related and its impact will be felt directly through aftertreatment systems' lifetime performance, the reviewer predicted, thus this work will support identification of problems, quantification of impacts and may facilitate future fuel specification development.

Reviewer 3:
The reviewer believed the project's probable contribution to a significant effect on fuel efficiency goals is limited. Slight improvements, the reviewer said, will not have a major impact. Improved combustion might have the largest impact on cooler fouling, in the reviewer's opinion, but combustion of fossil fuels will produce hydrocarbon exhaust gas.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer found resources, timeline and target to be well aligned and apparently reasonable based on the project target and objectives.

Reviewer 2:
The reviewer expressed some concern about the conclusions being drawn from the single engine test but recognized the cost impacts of replicate tests.

Applied Integrated Computational Materials Engineering for New Propulsion Materials: Charles Finney (Oak Ridge National Laboratory) - pm057

Presenter

Charles Finney, Oak Ridge National Laboratory.

Reviewer Sample Size

A total of three reviewers evaluated this project.

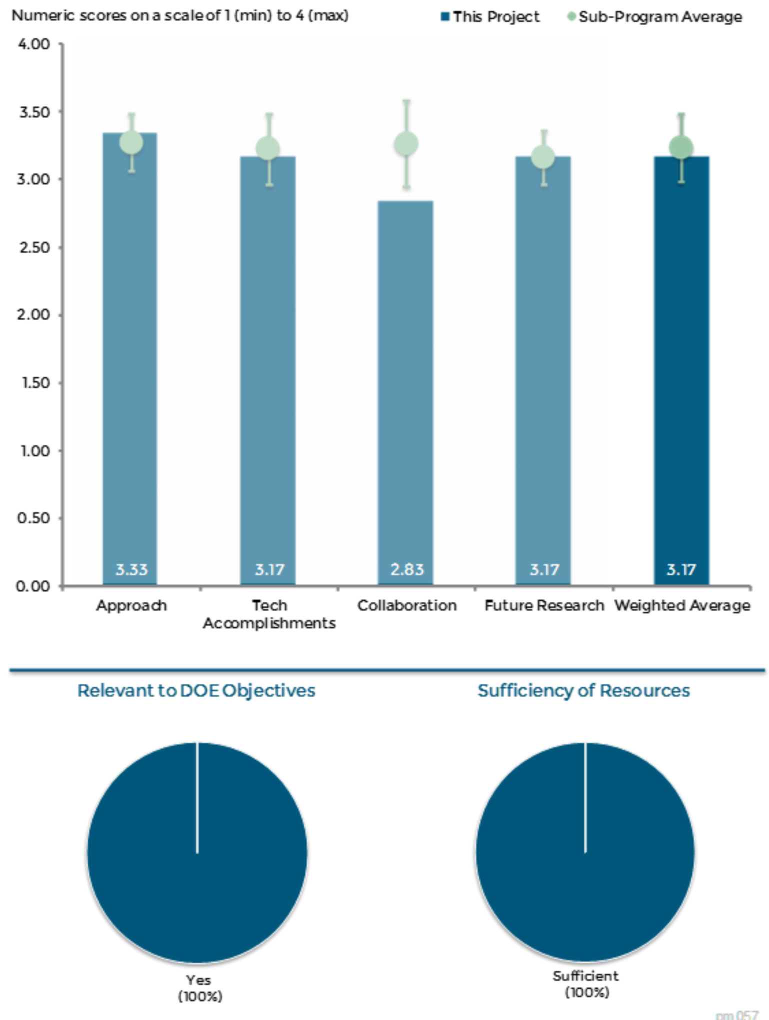


Figure 7-8 Applied Integrated Computational Materials Engineering for New Propulsion Materials: Charles Finney (Oak Ridge National Laboratory) – Propulsion Materials

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer found this work interesting and expected it would provide interesting results on material properties needs in the future. However, the reviewer added, the materials being studied, particularly the castings, will exhibit a range of properties locally in their geometry. The reviewer expressed a desire to see this accounted for in some manner. The reviewer further observed that coupling of manufacturing simulation tools with in-service modeling has been one of the innovations recently published by OEMs

Reviewer 2:

The presentation was directed almost entirely to Task 4, Modeling of Heavy Duty (HD) Engines, while the other three tasks were briefly summarized (and were previously reviewed), the reviewer observed, thus this review was based solely on Task 4. The reviewer described the approach as using CFD to estimate the thermal environment for peak cylinder pressures (PCP) operating points and finite element modeling (FEM) to evaluate effects of pressure and thermal environment on engine cylinder components. While it may be valuable and novel to incorporate CFD in this task, the reviewer went on, it does not utilize the principles of ICME significantly (i.e., multiscale integration). However, the coupled approach (CFD and FEM) appeared to the reviewer to be sensible and useful no matter what it is called. The reviewer considered that a much more thorough explanation of the intended limited goals would be appropriate, along with a concerted presentation of the next steps with an emphasis on the critical areas to study next.

Reviewer 3:

This project, the reviewer said, comprises four different tasks that are not related to each other. The approach for each task is different, the reviewer continued, and the first three tasks were presented last year. The fourth task – the focus of the presentation – is related to the materials for HD engines at higher operating temperatures, the reviewer concluded.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

This is a big project, the reviewer said, which seems to be quite productive in generating new material choices and setting up guidance on material limits.

Reviewer 2:

The reviewer noted that most subtasks under Task 4 had been started, with the exception of FEM (at the time the slides were submitted), but believed there was insufficient information to evaluate progress with respect to spending.

Reviewer 3:

The reviewer observed that the task predicted the peak stresses in the engine cylinder at 190 and 300 bar using both CFD and FEM simulation packages, but noted the analysis is not a coupled simulation. Nor was the simulation being compared to actual conditions in engines, the reviewer said, urging that efforts be made to measure the stresses or temperatures in actual working engines and compared to the simulation. This, the reviewer believed, will give assurance that the future predictions on material requirement are valid.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer acknowledged the listing of project partners but believed collaborations on the use of ICME tools to develop these material limits could be expanded, particularly by leveraging ICME projects from OEMs.

Reviewer 2:

The reviewer characterized the team of collaborators as consisting of several well-qualified institutions, but saw very little discussion of how these collaborators are contributing to the project. More specifically, the reviewer said it was unclear which collaborators are directly contributing to Task 4, the subject of this presentation. The reviewer recalled that this had been pointed out last year by others.

Reviewer 3:

This reviewer also felt that the actual contributions of the many collaborators mentioned were not clearly defined for this task.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer had no additional suggestions other than the ones provided above.

Reviewer 2:

The research proposed under the current funding plan demonstrates a good path forward for the remainder of this project, the reviewer said, and the materials property and characterization subtask should provide validation for the modeling effort. However, the reviewer saw no discussion of work planned as follow-on to this project.

Reviewer 3:

The plan includes a coupled modeling effort and identified the material property gaps, which the reviewer considered relevant, as the performance of the material is being simulated. However, the reviewer called for the plan to include some validation of simulation results.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer confirmed that the task overviewed in the presentation, with the tasks, support the DOE's objective.

Reviewer 2:

In part due to the methods development and in part due to the specific application, the reviewer said, the project does appear to address the DOE objectives.

Reviewer 3:

The ICME approach is identified as the faster way to develop new materials and solutions for improving fuel efficiency, this reviewer offered.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The resources should be sufficient, the reviewer believed, although finding it difficult to determine remaining funds for Task 4.

Development of Advanced High-Strength Cast Alloys for Heavy-Duty Engines: Rich Huff (Caterpillar, Inc.) - pm059

Presenter

Rich Huff, Caterpillar, Inc.

Reviewer Sample Size

A total of seven reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

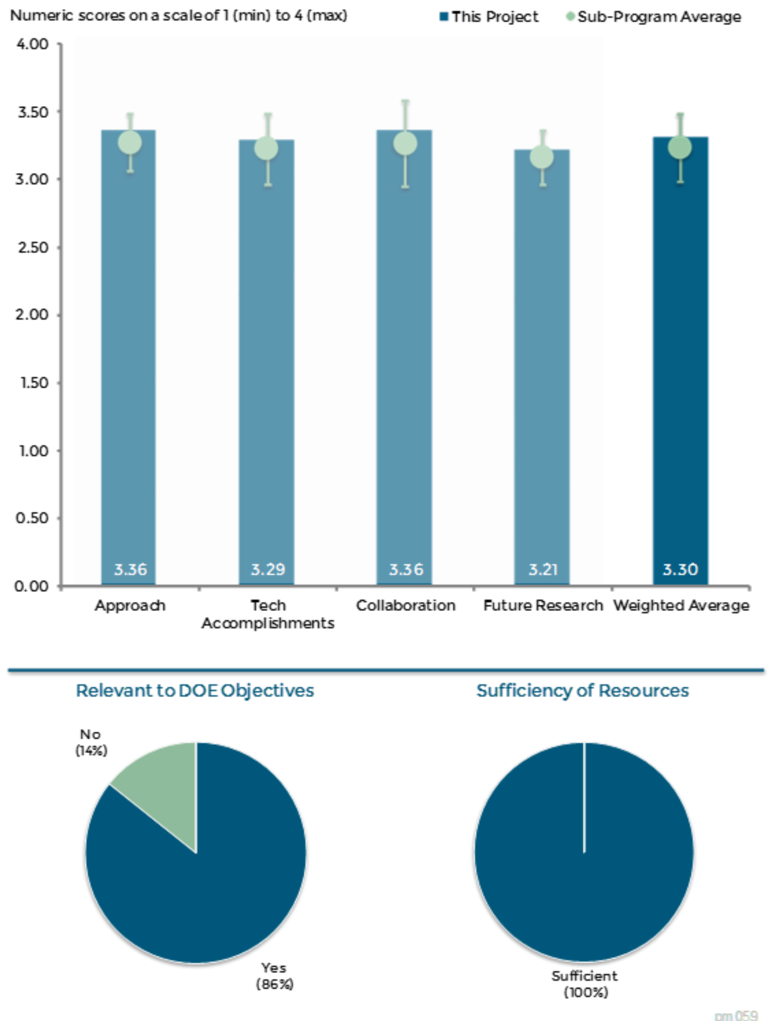


Figure 7-9 Development of Advanced High-Strength Cast Alloys for Heavy-Duty Engines: Rich Huff (Caterpillar, Inc.) – Propulsion Materials

Reviewer 1:
This is a well laid out project, with good achievements and their integration of models with the experimental work would be a major accomplishment, in the view of this reviewer.

Reviewer 2:
The project is using new methods to overcome old limitations on a problem which has a big impact on the major features of the engine, said this reviewer.

Reviewer 3:
This is a very challenging project, in the reviewer’s opinion, particularly the ICME element. Noting that cast iron is a complex structure extremely sensitive to processing, the reviewer said the team seems to be making good progress in understanding the role of various elements on particle nucleation through serial sectioning. The approach taken by this team is sound, the reviewer added.

Reviewer 4:
The reviewer found the project approach to be clearly and concisely described and noted the very well-planned use and implementation of ICME for initial alloy determination, moving on to experimental melts of compacted graphite iron, as well as the novel and traditional characterization methods. The systems design chart, the reviewer said, summarizes the approach nicely.

Reviewer 5:
This is year three of this long project, the reviewer noted, calling the approach well defined, with the ICME approach being followed to develop cast iron material for engine blocks.

Reviewer 6:
The reviewer characterized the program as combining a competent team with very defined applied goals, both of which, the reviewer said, provide obvious benefits. The graphite morphology and associated analyses the

reviewer found very interesting, noting that a number of advanced techniques were used. Despite the comprehensive set of casting trials that were carried out, the application of ICME (or its benefit) was not entirely clear to this reviewer, beyond the desire to refine the microstructure. Certainly with QuesTek as a partner, the reviewer said, there is no lack of understanding of ICME application, but the selection of castings and what specifically was guided by the ICME approach the reviewer believed were only addressed in very general terms. However, the reviewer concluded, the large spread of castings provides ample opportunity to relate microstructures with complex casting/composition relationships.

Question 2: Comments on Technical Accomplishments and Progress:

Reviewer 1:

The material exceeds compacted graphite iron (CGI) significantly, the reviewer noted; thus the target seems to be reached.

Reviewer 2:

Notwithstanding that several milestones are slightly delayed from the proposed schedule (or nearly so), the reviewer said, the progress has been considerable. The diverse set of evaluations performed thus far the reviewer termed impressive.

Reviewer 3:

The reviewer praised this project for its outstanding development and use of imaging tools to visualize macrostructure and provide data to support future model development. The reviewer noted the numerous references to model development, validation and comparisons, calling them key outcomes for DOE.

Reviewer 4:

The reviewer said the 3-D tomography work seemed to be a groundbreaking step in better defining the graphite microstructure of these materials. The activity to evaluate inoculant effects on nodule size and distributions the reviewer also believed will be of great value if it can eventually be published. Likewise, the reviewer deemed getting a better grip on nucleation and growth of the austenite and graphite will be valuable to the larger community – even if not all project goals are met – again provided the new understanding is published.

Reviewer 5:

The contractor goal of obtaining a fatigue endurance limit of 214 Pascal (MPa), the reviewer believed, is driving the research and development. The reviewer also noted substantial progress in performance requirements, alloy design, production and evaluation. Likewise, the reviewer discerned good progress in implementation of existing models, design and diagnostics associated with use of inoculation to understand and advance the eutectic coupled zone. Casting tasks and material evaluation are developing well, the reviewer concluded.

Reviewer 6:

The reviewer noted the very extensive characterization of the graphite morphology, and said the information on nucleation sites for graphite and austenite is excellent, predicting that it will be useful in controlling the final structure and hence the properties.

Reviewer 7:

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer praised the collaborations with Questek, Argonne National Laboratory and the University of Alabama-Birmingham as very good, noting that the role of each was clear and each partner had a substantial and important role.

Reviewer 2:
The reviewer described the assembled team as having a very diverse and complementary set of skills, from industrial/applied knowledge to ICME implementation to advanced characterization.

Reviewer 3:
The reviewer saw good evidence of interaction among the team members. Feedback and model enhancement based on the experimental results, in the reviewer's opinion, provide benefits for future development work and a rapid route to commercialization of the improved understandings.

Reviewer 4:
Caterpillar has assembled a very capable team of collaborators, said this reviewer.

Reviewer 5:
The team consists of university, federal national laboratory and supplier base representatives, according to the reviewer, with the role of each participant well defined and good progress being made in the project.

Reviewer 6:
The reviewer did not fully understand how the collaboration worked nor what expertise was shared.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
Noting that a considerable body of work regarding evaluation of the casting trials is still planned, the reviewer believed the progression of the program seemed to have organized the basic elements in a manner strongly indicating a successful basis for conclusions.

Reviewer 2:
The project offers a satisfactory approach to the road ahead, in this reviewer's opinion.

Reviewer 3:
Future task development is described in sufficient detail, the reviewer said, to demonstrate a high likelihood of meeting project objectives on time.

Reviewer 4:
The focus in future is to validate the models, in this reviewer's view.

Reviewer 5:
Thermal conductivity needs more attention, in this reviewer's estimation.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The project definitely supports DOE's petroleum conservation objective, the reviewer said, since it offers potential weight savings of say 100 pounds or increased PCP, which could bring up to a 1% increase in fuel economy.

Reviewer 2:
The reviewer described the project focus as being on elevating the performance of ICE components to allow more efficient operating conditions.

Reviewer 3:
Improved material properties, the reviewer pointed out, can enable more efficient diesel engines, leading to reduced petroleum consumption. Just as important, in this reviewer's opinion, improving ferrous metal models can speed the development of new alloys for further engine development.

Reviewer 4:
The project is exploring, developing and implementing ICME, alloy development and characterization techniques, yielding materials that will have improved properties, the reviewer observed, thus leading to improved strength capable of handling increased demands in engine environments with minimal additional costs.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The work speed seemed reasonable to this reviewer.

Reviewer 2:
The complexity of the remaining work is considerable, the reviewer said, but the program has demonstrated a distinct level of competence in the work carried out thus far. It is reasonable to assume, the reviewer concluded, that the program will progress as planned.

Reviewer 3:
The project appeared to this reviewer to be well funded and progress to date in the reviewer's opinion has been excellent with roughly half the DOE funds expended to date. The reviewer called attention to a note in the slide intended solely for reviewers indicating that there is insufficient budget and planning to reconstruct the 3-D primary solidification front. It appeared to the reviewer (Future Plans) that it is proposed to achieve this using x-ray radiography and/or computed tomography. If the task involves hardware development as well as unique data processing, the reviewer believed it is probably outside the scope of this project but that it would be a useful component of a follow-on project.

Integrated Computational Materials Engineering Guided Development of Advanced Cast Aluminum Alloys for Automotive Engine Applications: Mei Li (Ford Motor Company) - pm060

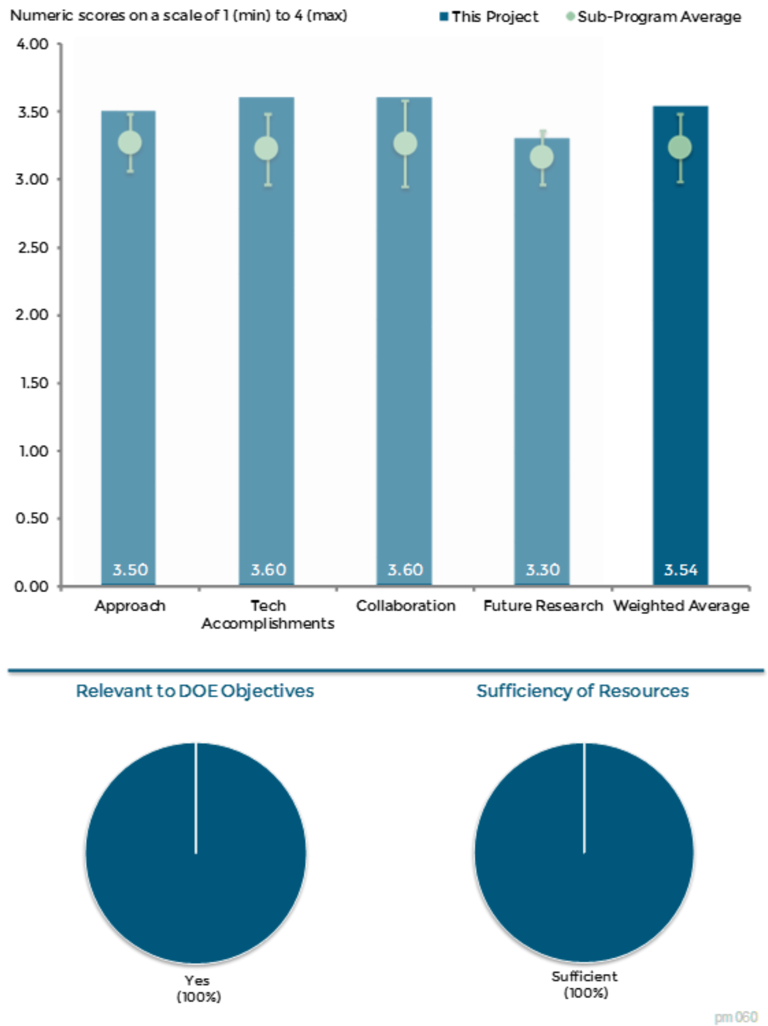


Figure 7-10 Integrated Computational Materials Engineering Guided Development of Advanced Cast Aluminum Alloys for Automotive Engine Applications: Mei Li (Ford Motor Company) – Propulsion Materials

Presenter

Mei Li, Ford Motor Company.

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

This is a great team and approach, the reviewer said, and the project is well planned and strongly focused on meeting the program objectives.

Reviewer 2:

The approach is specifically targeted at overcoming existing barriers, the reviewer affirmed, and focused on developing higher-performance (stronger) and more cost-effective alloys to address high temperatures. The project, the reviewer added, is also developing the design data and modeling tools necessary for success.

Reviewer 3:

Terming the technical challenge significant given the high diffusion rates of essentially all the possible element combinations, the reviewer was happy to see the use of ICME tools and experiments quickly to select a possible route to accomplish the objective.

Reviewer 4:

There appeared to this reviewer to be a good understanding of ICME regarding the tools or their deployment on an industrial scale, but in-depth characterization of some of the observed microstructures (specifically, the secondary precipitation phase), the reviewer noted, was not presented. Perhaps, the reviewer speculated, this development is in the intellectual property (IP) regime, so this omission was intentional. But one of the real benefits of ICME, the reviewer pointed out, is feeding existing microstructural evolution back into the modeling loop in order to optimize subsequent simulations or experimental matrices. The reviewer would have been very interested in seeing this approach outlined in detail.

Reviewer 5:

The project team considered the basic strengthening mechanisms in Al alloys and explained the shortcoming of the current alloys, the reviewer summarized. The approach is well planned, the reviewer went on, however, strength in Al alloys is derived from precipitation hardening and the major barrier for high-temperature stability is the coarsening of precipitates. It is necessary to identify precipitates which are stable at high temperatures (~300°C) if the strength has to remain stable, the reviewer cautioned. The project, the reviewer said, is working on some of the precipitates, which may be stable at these temperatures but this aspect was not reviewed in detail.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

This project seemed to this reviewer to have made a lot of progress toward development of alloys that would improve over those currently in use.

Reviewer 2:

The reviewer noted great progress toward achieving the material goals and deemed this work very encouraging.

Reviewer 3:

During the past year, the reviewer noted, project has appeared to build on its previous successes and has seen greater high-temperature performance due to improved materials selection and production processes, as well as having continued to move forward with data analysis process modeling. The reviewer's concern is that there still appears to be a great deal of work left to do before project completion in early 2016.

Reviewer 4:

Noting that the project is reported to be about 70% complete and scheduled for completion in February 2016, the reviewer cited substantial progress made in alloy design, casting process modeling and heat treatments, yielding increasingly higher yield strengths. However, the reviewer would have liked to see more discussion of progress on the gap analysis (Task 3) and a more complete description of the models employed.

Reviewer 5:

The presentation, the reviewer observed, concentrated on alloy development and heat treatment in coupon-level testing and the presenter explained that the ICME efforts are also ongoing. The reviewer noted that the analysis indicates the properties of the new alloy seem to meet expectations. While the complete heat treatment cycle was not provided, the reviewer assumed the high- temperature stability of precipitates had been considered and recalled that the presenter also indicated that variable cooling rates and their effect on precipitation were considered for the model.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

Noting that the project includes Alcoa, Nemak, Magma and the University of Michigan, all with specific duties under the project to supplement the work of an OEM (Ford as Project Lead/PI), the reviewer added that the project is also taking advantage of significant facilities available among the project participants.

Reviewer 2:

Collaboration seemed productive to this reviewer, given the fatigue results, microstructural assessment, and ICME tools.

Reviewer 3:

The reviewer cited an impressive team that shows a clear path to commercialize any resulting materials and to understand the costs of finished parts from any new materials.

Reviewer 4:
The collaboration was clearly described in the presentation, the reviewer noted, adding that the team has solid contributors in all aspects of the project.

Reviewer 5:
The roster of project collaborators covers the full spectrum of the supply chain, with material and service providers as well as Tier 1 suppliers and an OEM involved, the reviewer said.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The plan for future work is a reasonable progression from past and current work, according to this reviewer.

Reviewer 2:
The proposed future direction seems useful, in the estimation of this reviewer.

Reviewer 3:
There is a great deal of work left to accomplish in the eight months remaining in the project, the reviewer pointed out, including some steps that clearly require previous steps be completed first. The reviewer cited the PI's apparent confidence that all required activities can be completed on time. However, the reviewer drew attention to the identification of a prototyping effort considered an important addition to the project, one which may result in a six- to eight-month extension. Accordingly, the reviewer said, it would not be surprising if the completion dates for some required activities were similarly extended. The reviewer concluded by noting the PI's having indicated that future work in this area will be focused on ever-increasing engine temperature operational environments.

Reviewer 4:
The reviewer heard little discussion of how the model gap analysis is being done, although the task is listed in the future plans. This gap analysis, the reviewer said, is a key output for DOE.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The project is clearly focused on higher-performance materials for challenging operating environments, to improve engine efficiency, the reviewer summarized.

Reviewer 2:
The reviewer predicted that higher efficiency engines will be achievable with the success of this project.

Reviewer 3:
If the project continues to be successful, particularly in meeting the cost goals, the reviewer offered, this can result in design options for much more efficient spark-ignition engines. Depending on the results, the reviewer projected, this might also provide options for much lighter passenger car diesel engines, which would be a major contribution to meeting the DOE petroleum displacement goals.

Reviewer 4:
The reviewer summarized the project work as providing progress and leadership on implementation of ICME principles, advancing heat treatments that enable modification of precipitation microstructure, and as having developed new testing procedures (for thermomechanical and thermal fatigue) and explored new Al alloys.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

At this time, resources appear sufficient, in the opinion of this reviewer, who added that this will require continued monitoring if additional efforts identified are added to the project's scope, resulting in an extension.

Reviewer 2:

To this reviewer, the time to fully explore the cost of alloy replacement seemed short. However, the reviewer said an estimate would be satisfactory to justify the potential use of these new alloys.

Reviewer 3:

The reviewer cited the PI’s expressed confidence that sufficient resources are available to complete all tasks, but cautioned that there may be a shortfall in resources as the project winds up, as it was unclear to the reviewer that all tasks can be completed on schedule and within budget.

Computational Design and Development of a New, Lightweight Cast Alloy for Advanced Cylinder Heads in High-Efficiency, Light-Duty Engines FOA 648-3a: Mike Walker (General Motors) - pm061

Presenter

Mike Walker, General Motors.

Reviewer Sample Size

A total of six reviewers evaluated this project.

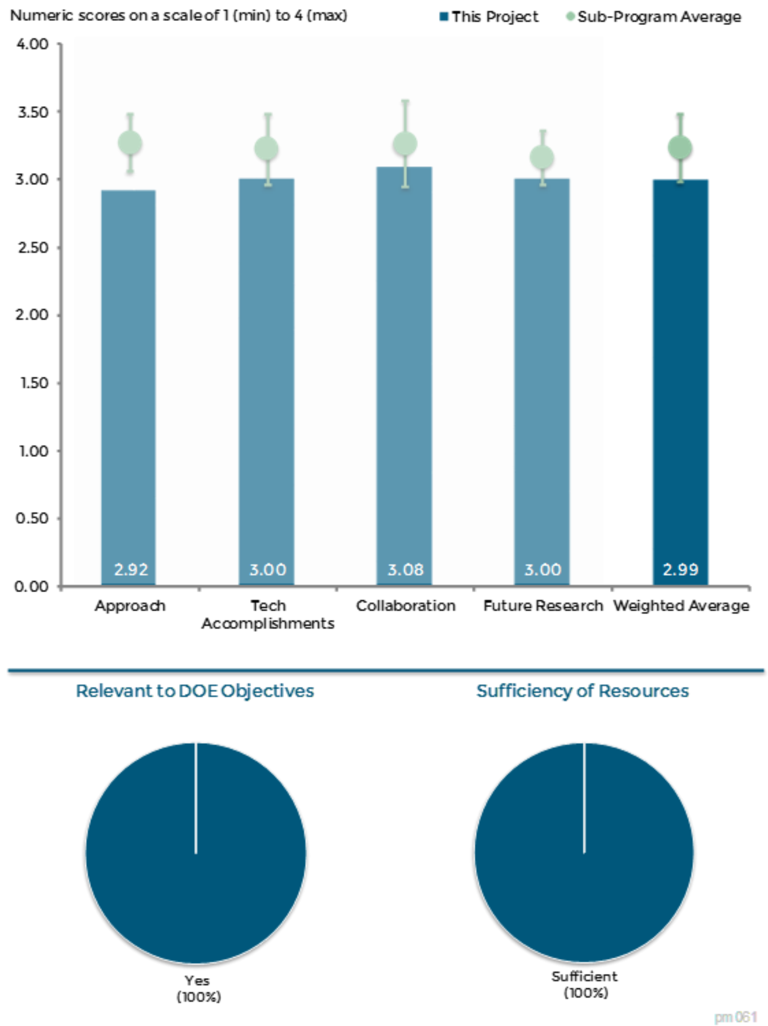


Figure 7-11 Computational Design and Development of a New, Lightweight Cast Alloy for Advanced Cylinder Heads in High-Efficiency, Light-Duty Engines FOA 648-3a: Mike Walker (General Motors) – Propulsion Materials

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

Saying the material temperature is given by its thermal conductivity, the reviewer called for the thermal conductivity to come into the evaluation process at an earlier stage and in a more systematic way, adding that there also seemed to be a need for better tools for thermal conductivity predictions.

Reviewer 2:

The approach seemed to this reviewer to be to evaluate minor changes to the existing chemistry based on the effect on the same classes of resulting precipitate phases. The reviewer thought a wholesale increase in strength properties using this approach seemed unlikely, particularly when the phases that form (omega, theta, beta) are not stable phases to begin with. The reviewer speculated that the modified chemistries being evaluated may be hiding some more transformational approach due to IP issues. The program can certainly be successful, the reviewer said, provided the target is not set excessively high, and the knowledge gained from this type of study is important to future ICME development.

Reviewer 3:

The reviewer described the research in this project as a combination of requirements development driven by metallurgical experts, modeling for alloy composition and properties, castings, advanced materials evaluation and model validation.

Reviewer 4:

Noting that consideration had been given to precipitate stability at 300°C, the reviewer also observed that alloying elements were chosen to provide stable microstructure at 300°C. Alloy selection was conducted in the previous year and characterization was the focus for Year 2, the reviewer noted in conclusion.

Reviewer 5:
The reviewer considered that this project is doing very good work, but found it unclear what the mechanism is for using all the developed information to improve the predictive models. Nonetheless, the reviewer saw clear indications of model improvement initiatives.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:
Calling the approach fundamentally right in view of the available modeling capabilities, the reviewer noted that how much better the engine becomes depends on how good thermal conductivity is. The reviewer also observed that very little information was given on concept alloys, which if successful, will not be available on the market.

Reviewer 2:
Noting that alloy characterization is closely tied to the model development, the reviewer said good understanding of alloy interactions had been achieved even though the required strength has not. The reviewer also pointed to the project team's having identified some of the gaps in the ICME approach.

Reviewer 3:
Although microstructural characterization and the relationship of microstructure to thermomechanical processing was evident to the reviewer, who commented that the use of TEM micrographs in the presentation comparing evolution but shown at different scales/orientations (Slide 9) as not informative. The reviewer said density functional theory (DFT) calculations should cover a much wider composition space than was presented, but acknowledged that that might have resulted from IP considerations.

Reviewer 4:
The modeling teams appear to have made good progress in model development and development of initial alloy designs, the reviewer said, and castings and validation steps had also been completed. While opining that results are moving in a positive direction, the reviewer perceived that key targets had not yet been achieved.

Reviewer 5:
The modeling discussed appeared to the reviewer to be focused on single material characteristics, which the reviewer cautioned can lead to sub-optimization. The strength versus ductility tradeoff did not appear to the reviewer to be adequately predicted from the modeling efforts. Noting that cost constraints were mentioned, the reviewer saw no discussion of the cost assessment process.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
Calling the project collaborators a good team, the reviewer found it particularly refreshing to see recyclability considered in the development process.

Reviewer 2:
GM, the reviewer said, has developed a strong team of collaborators making use of industrial and academic expertise for modeling and materials characterization.

Reviewer 3:
The team is composed of competent members, the reviewer said, but found their individual responsibilities unclear. Identifying Northwestern and QuesTek as the major collaborators, the reviewer described them as related in a number of respects, despite their being listed as two distinct entities. The range of computational and characterization results indicated to the reviewer that multiple contributors are providing input.

Reviewer 4:
The reviewer expressed the opinion that an Al producer would have strengthened the team and, if successful, would have supported commercialization.

Reviewer 5:
Despite the absence of a material provider on the team, it possesses enough expertise to develop new alloy compositions, in the view of this reviewer.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The simulation approach allows a wide selection in the first step, thus minimizing the risk of failure, according to the reviewer, who noted that the approach nevertheless will inevitably require several loops.

Reviewer 2:
To this reviewer, it seemed that the proposed future research was to refine the existing approach. Although it may prove successful, the reviewer allowed, inclusion of other potential alloying elements – not necessarily the more expensive variety such as scandium or silver mentioned in the presentation – would likely have a much more beneficial effect.

Reviewer 3:
The reviewer believed the future work list looked like a concerted exploratory material development push. It was not clear to the reviewer, however, what the plan is to evaluate and meet the team’s go/no-go milestone.

Reviewer 4:
To the reviewer, the planned future work represented a logical progression for the project. Parametric studies, DFT analysis and multiple castings with evaluation, the reviewer predicted, will yield a substantial amount of useful data. However, it was not clear to the reviewer that the sample space will be sufficiently covered to permit identification of the right mix of materials and processing to meet project goals.

Reviewer 5:
Noting that the strength of Al alloys is derived from precipitation hardening and that the major barrier to high-temperature stability is the coarsening of precipitates, the reviewer said it is necessary to identify precipitates which are stable at high temperatures (~300°C) if the strength is to remain stable. In the reviewer’s opinion, the project did not review this and appears not to plan to evaluate it in future work.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
Lower weight and/or higher loading will significantly support fuel economy improvements, the reviewer said.

Reviewer 2:
The goal of the program is to allow the more widespread deployment of lightweight materials in more demanding environments, the reviewer observed, adding that both serve to increase ICE efficiency.

Reviewer 3:
The reviewer described the project effort as working toward developing Al with higher strength properties through a combination of modeling, experiment, characterization and validation.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The program appears to have spent roughly a third of the funds as the halfway point nears, the reviewer observed. Based on the reported time extension and the delays associated with program startups, the reviewer believed the project funding level appeared to be tracking with progress.

Reviewer 2:

Calling the per-year resources reasonable, the reviewer cautioned that several loops should be expected, making a long project duration vital for success.

Reviewer 3:

Resources appeared sufficient to this reviewer, who found it unclear what had caused the delay in Budget Period 2 and how that affected the overall project goals.

High-Performance Cast Aluminum Alloys for Next Generation Passenger Vehicle Engines 2012 FOA 648 Topic 3a: Amit Shyam (Oak Ridge National Laboratory) - pm062

Presenter

Amit Shyam, Oak Ridge National Laboratory.

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

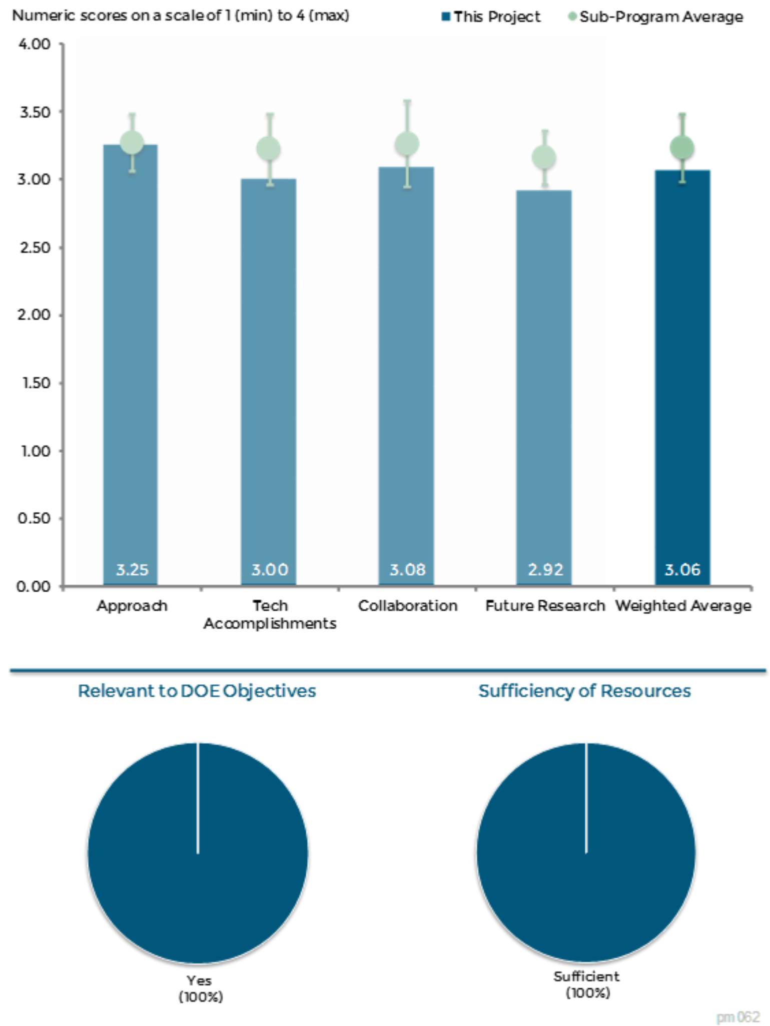


Figure 7-12 High-Performance Cast Aluminum Alloys for Next Generation Passenger Vehicle Engines 2012 FOA 648 Topic 3a: Amit Shyam (Oak Ridge National Laboratory) – Propulsion Materials

Reviewer 1:

The reviewer characterized the approach as a good program plan and a focus on assessment and integration of models.

Reviewer 2:

The team is certainly competent, the reviewer said, however the goals are somewhat convoluted. The reviewer saw the obvious goal as producing an alloy with higher capabilities, but was unclear as to how the ICME tools are being incorporated into subsequent heats. The characterization work the reviewer found impressive, but asked how it was being leveraged. Likewise, the reviewer queried whether there is specific distribution of theta phase, for instance, that is expected to prove more stable through nucleation strategies such as heat treatments or composition changes. How the microstructural evolution is being modeled, the reviewer continued. Based on what has been learned in the project, the reviewer believed that redefining the goals using microstructural terms rather than final properties would be very interesting.

Reviewer 3:

The reviewer characterized the approach as involving an iterative, coordinated effort of property development from ICME modeling geared toward surpassing limitations of properties and processing in the Gap Analysis. The approach, the reviewer added, includes engine testing, cost analysis and commercialization planning.

Reviewer 4:

The reviewer noted simply that the project is still in an early phase.

Reviewer 5:

Noting that down-selection is based on microstructure, the reviewer pointed out that composition is unknown, and that using only customized heat treatment may not insufficient or lead to an incorrect conclusion.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

In the opinion of this reviewer, this ORNL work is focused more on assessment of the ICME toolset than solely on developing a target material. This, the reviewer said is more likely to provide the detailed gap assessments that will result in long-term achievement of the DOE goals for the materials area.

Reviewer 2:

The reviewer noted progress in model development used for the preliminary design of new alloy compositions.

Reviewer 3:

The reviewer reiterated that the project is still in an early phase.

Reviewer 4:

A better understanding of the intricate balance of properties in the alloys of interest is being gained, the reviewer said, but the down-selection process seemed to the reviewer to need a more definite set of criteria.

Reviewer 5:

Reiterating that strength of Al alloys is derived from precipitation hardening and that the major barrier to high-temperature stability is coarsening of precipitates, the reviewer underlined the necessity of identifying precipitates which are stable at high temperatures (i.e., approximately 300°C) if the strength is to remain stable. The project has carried out analysis based on this approach, the reviewer said, but this has not resulted in an economical alloy; rather the alloy has proved expensive due to the alloy additions. Although justification was provided for concentrating on 30 micron dendrite arm spacing, the reviewer agreed, there was no plan provided for the contingency of larger-than-planned grain size.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

A good project team, the reviewer said.

Reviewer 2:

Following establishment of the CRADA, the collaboration team is complete, the reviewer noted, appearing to provide all the necessary expertise for successful implementation of the tasks.

Reviewer 3:

To this reviewer, it seemed that the industrial partners were largely slated for consultation rather than hands-on contributions. Castings, the reviewer noted, are still being produced using lab-based conditions, although Nemak is supplying master alloys. Thus the reviewer assumed that complementary analyses show casting results from ORNL heats are similar to industrial castings.

Reviewer 4:

Collaboration seems heavily focused on Fiat Chrysler Automobiles (FCA) and Nemak, the reviewer observed, but the roles of the other participants are less clear.

Reviewer 5:

The team has interaction with many partners who can adequately address the technical issue, the reviewer stated.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The plan for future work is logical, the reviewer said, and should lead to sufficient information development to determine if the approach can converge on materials that meet project targets.

Reviewer 2:
The plan looked very good to the reviewer, who believed it did not include enough time for loops and remarked the lack of heat conductivity feedback in the development loop

Reviewer 3:
The proposed future research is the critical step, in this reviewer's estimation - proving that the basis for improved alloys is adequate. It will be incumbent upon the PI, the reviewer went on, to provide ample evidence that this is the case, although the planned full-scale trial may help in that regard.

Reviewer 4:
The reviewer did not find the flow chart of future work helpful, because there seemed to the reviewer to be no exit or end to the work.

Reviewer 5:
The number of new alloys proposed seemed large (25) to this reviewer, who predicted that this would reduce the scope of characterization.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
There is huge fuel economy improvement potential in stronger materials, the reviewer asserted.

Reviewer 2:
Light-weighting is certainly an issue, in the reviewer's opinion. This program, the reviewer said, seeks to make use of advanced, lightweight materials more cost-effective, which will naturally result in a larger fraction of lightweight materials being deployed.

Reviewer 3:
The project directly addresses the need to produce Al alloys capable of higher- temperature strength and fatigue properties using the ICME principles, conventional experimental techniques and model validation, the reviewer stated.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The target is difficult to reach, the reviewer stated, but time is probably more limiting than money.

Reviewer 2:
Resources appeared ample to this reviewer for the ongoing and planned future work.

Reviewer 3:
The program, the reviewer said, is presented as being 38% complete. Noting that of the $3.5 million DOE share, $2.1 million will be spent at the end of FY 2015, the reviewer doubted that the burn rate could sustain the program through FY 2017, as stated. How the cost share from the industrial partners fits in, the reviewer

conceded, may explain this, although the commitment seemed vague when presented as approximately $2000 K.

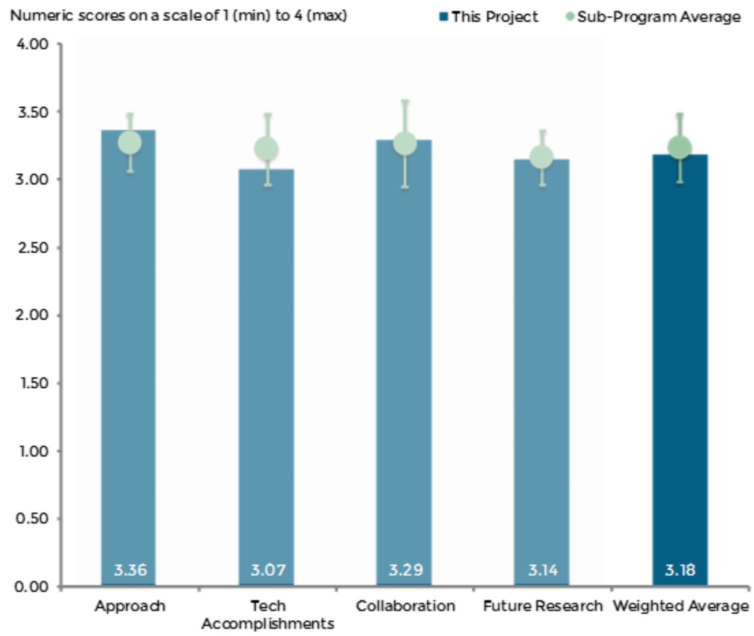
Alloy Development for High-Performance Cast Crankshafts: Rich Huff (Caterpillar, Inc.) - pm065

Presenter

Rich Huff, Caterpillar, Inc.

Reviewer Sample Size

A total of seven reviewers evaluated this project.



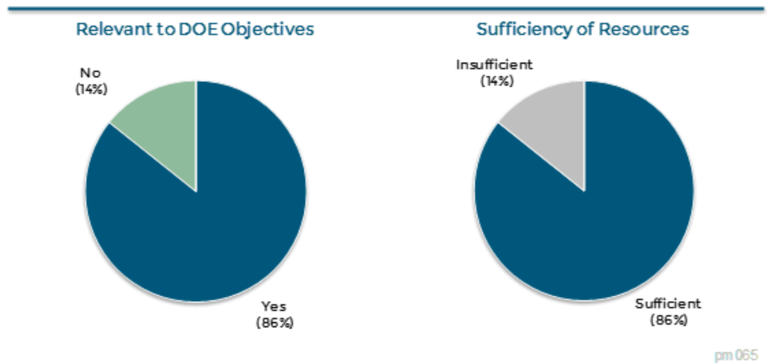


Figure 7-13 Alloy Development for High-Performance Cast Crankshafts: Rich Huff (Caterpillar, Inc.) – Propulsion Materials

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer praised a good start to the project and modeling, adding that the overall project appeared well designed and appropriately focused.

Reviewer 2:

This, the reviewer averred, is a well-planned project with a good distribution of tasks and milestones. The approach the reviewer considered clear and logical, addressing key DOE interests. The reviewer also praised the system and materials design graphics as very useful for setting the stage for the work to be performed.

Reviewer 3:

The program to date shows a great deal of competence with regard to the analysis of cooling rates and their effects on final properties of interest, in this reviewer's view. The reviewer also found the comprehensive systems design chart a powerful visual aid. The reviewer praised the ICME roadmap as also more complete and highly informative by comparison to those shown in other presentations.

Reviewer 4:

The multi-disciplinary approach is very good and considers many variables including structure, alloy composition and heat treatment, in the view of this reviewer.

Reviewer 5:

The approach appeared sound to the reviewer, who thought, however, that it would have been preferable to see a commercial foundry involved from the beginning as a cost-share partner, along with the university, for an effort as challenging as steel casting. Nevertheless, the reviewer said, it appeared that progress was being made in identifying potential foundries.

Reviewer 6:

The project relevance was described, the reviewer agreed, but no quantifications or examples were given.

Reviewer 7:

In the presentation, the reviewer said, the design approach was clear, showing that the model predictions showed some discrepancy with the data. Are there any plan to understand this gap, the reviewer wondered.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The initial milestones associated with requirements for end product, materials and processes have been completed, the reviewer said, and the systems and materials design charts allow verification of progress on tasks. The reviewer observed that model development is driving the alloy design and the casting process.

Reviewer 2:

Terming the modeling and predictive work reasonable for this point in the project, the reviewer noted a good beginning for the experimental program.

Reviewer 3:

The ICME prediction has identified many alloy variations for testing and development, the reviewer said.

Reviewer 4:

How individual analyses would be carried out based on altering (and optimizing) compositions was not entirely clear to the reviewer, who noted that the program is nearing the halfway point. Specific identification of properties of interest may provide a relatively straightforward final evaluation based on yield strength (YS) and UTS (and, presumably, fatigue), the reviewer said, but to be effective, the looping of information back into the ICME modeling flow will require analysis of considerably more factors than strength levels.

Reviewer 5:

The advantages are described, the reviewer noted, but no quantifications or examples were given.

Reviewer 6:

Progress has been limited, the reviewer observed, with only hardness data from cast alloys thus far. However, the reviewer acknowledged, it is very early in the project.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The team is diverse and individual responsibilities were presented with a level of detail this reviewer found particularly satisfying. Employment of Argonne National Laboratory's Advanced Photon Source and associated results were not addressed at this point in the program, according to the reviewer.

Reviewer 2:

This is a good project team, the reviewer said, the combination of Caterpillar and GM crankshaft requirements and objectives strengthening the project. The reviewer asked if the cost targets will be assessed for each company, or for just one.

Reviewer 3:

Caterpillar has assembled a very well-coordinated team of collaborators, in this reviewer's view, and the initial collaborative effort with General Motors on performance needs is a good driver for the project.

Reviewer 4:

Collaborations appear sound to the reviewer, who insisted that a foundry partner is essential in a project with a limited budget.

Reviewer 5:

Though praising a good team set-up, the reviewer found it difficult to understand from the presentation who in the team did what.

Reviewer 6:

Noting that two OEMs are involved in the development work, the reviewer added that their respective cost structures may differ based on their production volumes. The 110% cost increase for both was not explained to this reviewer's satisfaction.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

Deeming the main barriers well identified, the reviewer could see no alternative development pathways.

Reviewer 2:

There is a clear plan for future efforts, the reviewer said, leading to an ICME-driven, and experimentally validated crankshaft prototype.

Reviewer 3:

The reviewer discerned a distinct level of complexity remaining in the program, specifically regarding the analysis of different compositions and leveraging this analysis with the comprehensive process analysis modeling and evaluation. This effort, the reviewer said, will be the true measure of the progress and ultimate success of the overall program.

Reviewer 4:

Steel cleanliness will be a major challenge for such a fatigue-driven component, the reviewer predicted. It would be better, the reviewer continued, if next year's review includes a strategy for increasing the cleanliness and quality of the casting process. Likewise, the reviewer expressed a desire to see work proposed on characterizing casting defects as a function of alloy composition, pouring conditions and local cooling rates.

Reviewer 5:

Casting is the challenge, as the component must be produced with minimum defects, the reviewer stated. The solidification modeling, the reviewer continued, can be a useful tool in identifying the optimum (vertical or horizontal) casting process.

Reviewer 6:

The reviewer considered that the expected use of the results of this research is to facilitate redesign of the casting process. Lots of integration tools are available, the reviewer noted, but how to improve the efficiency of integration and reliability – which will lead to robust analysis –is the key. The reviewer expressed a desire to see additional effort on that side to facilitate a functionally excellent approach.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

Cast crankshafts offer the potential for weight savings in vehicles, the reviewer noted.

Reviewer 2:

The PI presented a compelling set of benefits for the reduction in weight of the major rotating components (specifically the crankshaft), the reviewer said, and for the associated trickle-down effects regarding subsequent lightening of other components (such as the block that must contain the considerable rotation-based stresses).

Reviewer 3:

Yes, the reviewer said, but the weight saving target is not well motivated and can be questioned.

Reviewer 4:

The benefit of this project to improving engine efficiency was unclear to the reviewer. The underlying goal seemed to the reviewer to be reducing the cost of higher-performance crankshafts. This clearly benefits the partner engine companies, the reviewer acknowledged, because success would allow them to replace forged crank with lower-cost cast cranks. If this cost reduction results in turn in greater penetration of higher peak cylinder pressure and higher- efficiency engines, this project will contribute to the DOE objective, the reviewer concluded.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

It appeared to this reviewer that both the three-year project duration and funding resources are less than ideal for developing a highly fatigue-resistant, cast steel crankshaft, because both materials and processing development are required.

Reviewer 2:

This project, the reviewer predicted, will either work or not work and spending more would not help much.

Reviewer 3:

From a budget standpoint, the reviewer noted, the program is still in its infancy, with relatively little of the overall program funding having been spent thus far. Presumably, the reviewer speculated, the remaining budget is sufficient to cover the remaining scope.

Reviewer 4:

Resources appear to be sufficient, in the opinion of this reviewer.

Acronyms and Abbreviations

3D	Three dimensional
Al	Aluminum
AMR	Annual Merit Review
ANL	Argonne National Laboratory
C	Carbon
CF	Carbon fiber
CFD	Computational Fluid Dynamics
CGI	Compacted graphite iron
CRADA	Cooperative Research and Development Agreement
CTE	Coefficient of thermal expansion
Cu	Copper
DFT	Density functional theory
DOC	Diesel oxidation catalyst
DOE	Department of Energy
EDT	Electric Drive Technologies
EGR	Exhaust Gas Recirculation
EM	Electric motor
EV	Electric Vehicle
FCA	Fiat Chrysler Automobiles
FEM	Finite element modeling
FSP	Friction Stir Processing
FY	Fiscal Year
HD	Heavy-Duty
ICE	Internal combustion engine
ICME	Integrated Computational Materials Engineering
IP	Intellectual Property
K	Potassium

LD	Light-duty
Mg	Magnesium
MPa	Megapascal
Na	Sodium
Ni	Nickel
NOx	Oxides of Nitrogen
NREL	National Renewable Energy Laboratory
OEM	Original Equipment Manufacturer
ORNL	Oak Ridge National Laboratory
Pa	Pascal
PCP	Peak cylinder pressures
PE	Power electronics
PI	Principal Investigator
PNNL	Pacific Northwest National Laboratory
R&D	Research and Development
RS	Rapidly solidified
SAE	Society of Automotive Engineers
Si	Silicon
TEM	Transmission electron microscope
UTS	Ultimate tensile strength
VTO	Vehicle Technologies Office

8. Technology Integration

Our nation's energy security depends on the efficiency of our transportation system and on which fuels we use. Transportation in the United States already consumes much more oil than we produce here at home and the situation is getting worse. The U.S. Department of Energy's (DOE's) Vehicle Technologies Office (VTO) supports research and development (R&D) that will lead to new technologies that reduce our nation's dependence on imported oil, further decrease vehicle emissions, and serve as a bridge from today's conventional powertrains and fuels to tomorrow's hydrogen-powered hybrid fuel cell vehicles. VTO also supports implementation programs that help to transition alternative fuels and vehicles into the marketplace, as well as collegiate educational activities to help encourage engineering and science students to pursue careers in the transportation sector. Following are some of the activities that complement the VTO's mission.

Energy Policy Act of 1992

VTO administers programs in support of the Energy Policy Act of 1992 (EPAct), which was passed to reduce our nation's reliance on foreign petroleum and improve air quality. Officially known as Public Law 102-486, EPAct includes provisions that address all aspects of energy supply and demand. EPAct's regulatory fleet programs require federal, state, and alternative fuel provider fleets to annually acquire a certain percentage of alternative fuel vehicles (AFVs), which are capable of operating on nonpetroleum fuels.

EPAct further requires covered fuel providers to use alternative fuels in their AFVs. Since 1992, regulated fleets have helped build a core market for AFVs and have displaced more than 100 million gasoline gallon equivalents (GGE) of conventional fuels.

Clean Cities

Clean Cities supports the voluntary side of EPAct. Clean Cities was created in 1993 to provide technical, informational, and financial resources to both regulated fleets and voluntary adopters of alternative fuels.

As the primary deployment arm of VTO, Clean Cities' mission is to advance the nation's economic, environmental, and energy security by supporting local decisions to adopt practices that contribute to the reduction of petroleum consumption. Clean Cities carries out this mission by working with more than 90 coalitions throughout the United States. Among its 4,800 stakeholders are local, state, and federal government agencies; commercial fleets; automakers; fuel suppliers; utility companies; and professional associations. Since its inception, Clean Cities has displaced more than 1 billion GGE of petroleum through the use of alternative fuels and AFVs, idle reduction technologies, fuel economy measures, and fuel blends.

Educational Activities

In addition to research, the VTO supports post-secondary educational activities, such as competitions and technology development programs for engineering students interested in advanced transportation research.

Subprogram Feedback

DOE received feedback on the overall technical subprogram areas presented during the 2015 Annual Merit Review (AMR). Each subprogram technical session was introduced with a presentation that provided an overview of subprogram goals and recent progress, followed by a series of detailed topic area project presentations.

The reviewers for a given subprogram area responded to a series of specific questions regarding the breadth, depth, and appropriateness of that DOE VTO subprogram's activities. The subprogram overview questions are listed below, and it should be noted that no scoring metrics were applied. These questions were used for all VTO subprogram overviews.

Question 1. Was the program area, including overall strategy, adequately covered?

Question 2. Is there an appropriate balance between near-, mid- and long-term research and development?

Question 3. Were important issues and challenges identified?

Question 4. Are plans identified for addressing issues and challenges?

Question 5. Was progress clearly benchmarked against the previous year?

Question 6. Are the projects in this technology area addressing the broad problems and barriers that the Vehicle Technologies Office (VTO) is trying to solve?

Question 7. Does the program area appear to be focused, well-managed, and effective in addressing VTO's needs?

Question 8. What are the key strengths and weaknesses of the projects in this program area? Do any of the projects stand out on either end of the spectrum?

Question 9. Do these projects represent novel and/or innovative ways to approach these barriers as appropriate?

Question 10. Has the program area engaged appropriate partners?

Question 11. Is the program area collaborating with them effectively?

Question 12. Are there any gaps in the portfolio for this technology area?

Question 13. Are there topics that are not being adequately addressed?

Question 14. Are there other areas that this program area should consider funding to meet overall programmatic goals?

Question 15. Can you recommend new ways to approach the barriers addressed by this program area?

Question 16. Are there any other suggestions to improve the effectiveness of this program area?

Responses to the subprogram overview questions are summarized in the following pages. Individual reviewer comments for each question are identified under the heading Reviewer 1, Reviewer 2, etc. Note that reviewer comments may be ordered differently; for example, for each specific subprogram overview presentation, the reviewer identified as Reviewer 1 in the first question may not be Reviewer 1 in the second question, etc.

Subprogram Overview Comments: Linda Bluestein (U.S. Department of Energy) – ti000

Question 1: Was the program area, including overall strategy, adequately covered?

Reviewer 1:

The reviewer said yes, the overall strategy to implement policies and initiatives by facilitating change on a local and national level was described.

Reviewer 2:

The reviewer said yes, program area and overall strategy of program was covered well in the overview presentation.

Reviewer 3:

The reviewer said that the Technology Integration (TI) program was more than adequately covered. This program includes a number of moving parts, which were all clearly addressed in the Overview. While many may focus solely on the Clean Cities element of TI, the overview also addressed the other critical pieces including regulatory/legislative projects, student competitions, and Graduate Automotive Technology Education (GATE). This program, being something other than a research & development (R&D) program, is often difficult for people to understand, and the overview clearly laid out all these pieces, their rationale, and how they fit in with the rest of VTO.

Question 2: Is there an appropriate balance between near- mid- and long-term research and development?

Reviewer 1:

The reviewer agreed that the program in the near-term currently saved 1 billion gallons of petroleum in a single year. In the mid- and long-term there is a goal to reduce petroleum by 2.5 billion gallons per year.

Reviewer 2:

The reviewer said that given that this area is largely about deployment, the primary focus is appropriately on near-term elements. It includes some longer-term focus on educating the next generation of experts.

Reviewer 3:

The reviewer said yes, program management does a great job balancing the immediate needs, as well as visionary and planning requirements to meet mid- and long-term research and development.

Question 3: Were important issues and challenges identified?

Reviewer 1:

The reviewer said yes, the challenge of increasing public awareness and consumer acceptance as well as the need to implement next steps when R&D is completed were identified.

Reviewer 2:

The reviewer said that barriers and needs were clearly identified in the presentation.

Reviewer 3:

The reviewer noted that the biggest issue/challenge that the program faces is the need for more alternative fuel vehicles in service to reduce petroleum usage.

Question 4: Are plans identified for addressing issues and challenges?

Reviewer 1:

The reviewer remarked that through the deployment efforts to accelerate market transformation and the Clean Cities effort to reduce petroleum use these challenges are addressed. The reviewer detailed that the portfolio of alternative fuel use technologies, idle reduction, and the use of hybrid vehicles to help improve fuel economy are all ways to address identified issues and challenges.

Reviewer 2:

The reviewer said that more than most areas within VTO, this area is fully focused on approaches to address issues and challenges. This is necessary because of its primarily near-term focus on moving technologies into the hands of users, or in addressing regulatory requirements. The reviewer noted that the student programs (competitions and GATE) are also well-planned efforts meeting somewhat longer-term needs.

Reviewer 3:

The reviewer said yes, the program conducts five-year strategic planning sessions, allowing stakeholders and other industry partners to participate, in order to set goals and objectives to move the program forward. In addition, new tools and resources, continued technical assistance, and funding opportunities/assistance are provided to continue to move the industry and program activities forward.

Question 5: Was progress clearly benchmarked against the previous year?

Reviewer 1:

The reviewer said that there continues to be very good progress in this program annually. Clean Cities saved 1 billion gallons of petroleum, the National Clean Fleet Partners has grown to 26 companies, and the electric vehicle supply equipment (EVSE) station locator program has been a success with over 200,000 users. The reviewer commented that these are very good accomplishments.

Reviewer 2:

The reviewer said that continued progress against key metrics was clearly identified, focused primarily on petroleum displacement from Clean Cities. In addition, accomplishments of the other activities within TI were also provided, particularly compliance level for regulatory activities and specific accomplishments for student programs.

Reviewer 3:

The reviewer said yes, the 2014 program overview was provided to allow for clearly benchmarked progress against the previous year.

Question 6: Are the projects in this technology area addressing the broad problems and barriers that the Vehicle Technologies Office (VTO) is trying to solve?

Reviewer 1:

The reviewer said that the overall activities of Clean Cities, legislative development and rulemaking, advanced vehicle competitions, and the GATE program all help address the barriers that VTO is working on.

Reviewer 2:

The reviewer said that this area absolutely addresses the overall problems and barriers facing VTO. This area, with its focus on deployment, is the final step necessary for VTO technologies to actually make a difference. The reviewer noted that if technologies are not used, no petroleum is displaced or reduced, and that is exactly what TI focuses on. In addition, VTO and the technologies that it focuses on will have continuing needs for new experts to contribute in the future, the primary focus of the student programs.

Reviewer 3:

The reviewer said that each of the projects in this technology area addresses the broad problems/barriers of the VTO and contributes to the quest to move our nation away from petroleum-based fuel. This includes forming and managing the nationwide coalition network of coordinators; developing and supporting the development of consumer information, outreach, and education; providing technical and problem solving assistance; and funding the development of numerous projects that align with the program mission and goals.

Question 7: Does the program area appear to be focused, well-managed, and effective in addressing VTO's needs?

Reviewer 1:

The reviewer said that as shown through the accomplishments over the past year, this program is very well-managed and definitely addresses VTO needs.

Reviewer 2:

The reviewer pointed out that TI, because of its nature, has to address a number of needs for VTO. Given this, however, the TI program has focused on the key areas of contribution to meet overall VTO goals. Thus, it focuses on education/outreach and easing deployment (Clean Cities), working with regulated fleets (regulatory activities), and developing the next generation of experts (student competitions and GATE). The reviewer pointed out that in addition, this program clearly leverages relatively meager resources to accomplish a great deal on a national basis.

Reviewer 3:

The reviewer said yes, the program area appears to be focused, well-managed, and effective in addressing VTO's needs. Through the development of a franchise model, the Clean Cities program is able to be on the ground in nearly 100 local areas delivering a consistent message to reduce dependence on petroleum.

Question 8: What are the key strengths and weaknesses of the projects in this program area? Do any of the projects stand out on either end of the spectrum?

Reviewer 1:

The reviewer said that a key strength of the overall program continues to be the Clean Cities activity. The number of partners across the country and the amount of fuel displaced makes it stand out as a top program in VTO.

Reviewer 2:

The reviewer said that the Clean Cities program, with its management team and coalition network, is an extremely important program responsible for a huge amount of the success and deployment of alternative fuel vehicles nationwide. This program operates like veins in a body – instrumental to the blood flow – necessary for the success of the alternative fuels industry. The reviewer identified that a weakness is the structure of the coalition network, limiting the financial support of the coalitions and therefore limiting the impact of some of the coalitions who seem to struggle financially to survive.

Reviewer 3:

The reviewer said that the real strength of the program is having highly experienced personnel and partners who have together developed successful approaches over the years - Clean Cities coalitions, the student competitions, the regulatory implementation activities, and GATE. The success of these approaches has clearly been demonstrated over the years. In particular, Clean Cities' focus on mobilizing stakeholders at the local level has been critical to significant petroleum displacement. The reviewer noted that, in addition, the use of the national laboratories has also been key, and has included development of projects, programs, and tools useful not only within the TI program, but also to the general public (such as the Fuel Economy Guide and its website, as well as the Alternative Fuel Data Center). The reviewer identified that the key weakness is the lack of a stronger bridge to VTO's R&D programs, so that TI can more fully function as the demonstration and deployment arm of VTO.

Question 9: Do these projects represent novel and/or innovative ways to approach these barriers as appropriate?

Reviewer 1:

The reviewer noted that EcoCar3 and the GATE programs are instrumental in the development of future engineers and scientists.

Reviewer 2:

The reviewer detailed that the design of Clean Cities, the regulatory activities, and the student programs (competitions and GATE) is highly innovative. In most cases, these activities likely represent the only examples of these types of approaches anywhere.

Reviewer 3:

The reviewer said yes, especially through competitive awards, the project barriers are dealt with in novel and innovative ways, with each proposal bringing new thoughts, talents, and experiences that together better contribute to the breakdown of barriers.

Question 10: Has the program area engaged appropriate partners?

Reviewer 1:

The reviewer said that there is a very good set of partners developed through the Clean Cities program that is a major reason for the success of that activity. The EcoCar 3 and GATE programs also have developed good relationships with original equipment manufacturers (OEMs), suppliers, and colleges and universities.

Reviewer 2:

The reviewer pointed out that collaboration has been the key implementing method for the TI program. This has included nearly 100 Clean Cities coalitions made up of thousands of stakeholders, as well as manufacturers, fuels industry representatives, national fleets, and numerous university programs. The reviewer pointed out that this is in addition to working with over 300 regulated fleets. Similarly, the regulatory and student programs also include a very high level of engagement with partners, as evidenced by their successes.

The reviewer detailed that a key need, however, is building a stronger bridge between the deployment opportunities under TI and the demonstration needs for technologies developed under VTO's R&D programs. More R&D projects need to include specific actions regarding demonstration in the hands of knowledgeable users, such as identified through Clean Cities (such as either individual coalition stakeholders or National Clean Fleet Partners).

Reviewer 3:

The reviewer said yes, and detailed that partners are engaged in many ways – on a local and statewide basis by coalitions and on a national basis by the program headquarters. There is always opportunity for new partnerships and the program appears to always be looking for those opportunities.

Question 11: Is the program area collaborating with them effectively?

Reviewer 1:

The reviewer said yes, the program seems to be collaborating with the partners very effectively.

Reviewer 2:

The reviewer said that the TI programs focus continuously on collaborating with stakeholders/partners, even to the point of bringing hundreds in to participate in a recent Clean Cities Strategic Planning Workshop, aimed at developing the next five-year strategic plan. The regulatory activities also regularly interact with stakeholders (regulated fleets), resulting in the 100% compliance level identified in the presentation. The reviewer said that the successes of the student programs also are due to high levels of effective collaboration.

Reviewer 3:

The reviewer said yes. The program members are expert collaborators as that is the way they conduct their business. It is a necessity. The reviewer noted that program members cannot do the work without effective collaboration.

Question 12: Are there any gaps in the portfolio for this technology area?

Reviewer 1:
The reviewer said no, there do not appear to be any gaps in this area.

Reviewer 2:
The reviewer said that the only potential gap is aggressively being closed through the recruitment of additional Clean Cities coalitions in areas not yet represented. There are very few states that do not have such representation at this time.

Reviewer 3:
The reviewer said that if greater funding were provided, more deployment grants under Clean Cities could be useful. The reviewer noted that in addition, there is a need for a stronger link between the deployment and R&D programs as identified in question 10 above. However, funding for demonstration efforts would need to come from the R&D side, and not out of TI's relatively meager budget.

Question 13: Are there topics that are not being adequately addressed?

Reviewer 1:
The reviewer said that all topics are being addressed sufficiently.

Reviewer 2:
The reviewer said that the alternative fuel vehicle industry is constantly moving and therefore there are always new topics to be addressed. The program does a very good job staying on top of the needs of the changing industry.

Reviewer 3:
The reviewer emphasized there is a need to take advantage of the opportunities to put R&D technologies ready for demonstration in the hands of appropriate users identified by the TI programs. Greater coordination is needed with other agencies, many of which are much better sources of funding for deployment programs than DOE.

Question 14: Are there other areas that this program area should consider funding to meet overall programmatic goals?

Reviewer 1:
The reviewer suggested that consideration should be given to increasing the level of funding for this overall activity. This is one area that shows real near-term benefits instead of potential long-term benefits after R&D is complete.

Reviewer 2:
The reviewer suggested additional training, professional development, and creative funding (outreach support, etc.) for the coordinators.

Reviewer 3:
The reviewer noted that there are several areas that could use additional funding, if it were made available. The reviewer suggested: joint VTO TI/R&D demonstrations; more deployment funding opportunities under Clean Cities; stronger coalition support under Clean Cities; and more outreach under regulatory activities (including jointly with Clean Cities).

Question 15: Can you recommend new ways to approach the barriers addressed by this program area?

Reviewer 1:
The reviewer said no, the barriers are being adequately addressed for the funding level of the program.

Reviewer 2:

The reviewer pointed out that the program has a very strong reputation. The fleet partnership project is hugely successful. The reviewer suggested that perhaps an OEM partnership project similar to this would bring added support for getting AFVs deployed.

Reviewer 3:

As previously indicated, the reviewer recommended a stronger tie between deployment efforts and R&D technology demonstrations, relying upon the network of appropriate users already developed. Student programs are also critical, leading to the next generation of experts, and must be continued. The reviewer suggested that regulatory activities could also be a greater catalyst for alternative fuel efforts if even greater outreach were conducted (with additional funds), much in coordination with Clean Cities.

Question 16: Are there any other suggestions to improve the effectiveness of this program area?

Reviewer 1:

The reviewer said that the effectiveness of the program could be improved with the addition of increased funding.

Reviewer 2:

The reviewer noted that some of the Clean Cities coalitions are prospering, while others are struggling. Each coalition is such a vital part of the success of the program mission. The reviewer suggested that perhaps there could be jobs that coalitions in need could bid on to support the national efforts of the program (or even local efforts - coalitions helping coalitions) that would help them keep the local coalition in need afloat.

Reviewer 3:

The reviewer had no suggestions.

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.

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Fuel Economy Guide and fueleconomy.gov Website	Saulsbury, Bo (ORNL)	8-11	3.40	3.80	3.20	3.60	3.60
Fuel Economy Information Project - Research, Data Validation, and Technical Assistance Related to Collecting, Analyzing, and Disseminating Accurate Fuel Economy Information	Saulsbury, Bo (ORNL)	8-16	3.40	4.00	3.40	3.20	3.68
Alternative Fuel Station Locator	Hudgins, Andrew (NREL)	8-21	3.40	3.60	3.80	4.00	3.63
Alternative Fuels Data Center and API	Levene, Johanna (NREL)	8-25	3.60	3.60	3.60	3.60	3.60
Clean Cities Coordinator Resource Building and National Networking Activities	Dafoe, Wendy (NREL)	8-29	3.00	2.80	3.80	3.60	3.08

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Clean Cities “Tiger Team” Technical and Problem Solving Assistance	Gonzales, John (NREL)	8-32	3.60	3.80	3.80	3.80	3.75
Collegiate Programs: Advanced Vehicle Technology Competitions (AVTC), Graduate Research Assistants (GRCs), and Clean Cities University Workforce Development Program (CCUWDP)	Rood , Marcy (ANL)	8-35	3.50	3.75	3.25	3.00	3.53
Alternative Fuel Tools and Technical Assistance Activities	Rood, Marcy (ANL)	8-38	3.50	3.75	3.50	3.75	3.66
Overall Average			**3.43**	**3.64**	**3.54**	**3.57**	**3.57**

Fuel Economy Guide and fueleconomy.gov Website: Bo Saulsbury (Oak Ridge National Laboratory) - ti056

Presenter

Bo Saulsbury, Oak Ridge National Laboratory.

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Project Approach to supporting deployment of petroleum reduction technologies and practices, alternative fuel vehicles, infrastructure and related efforts—the degree to which the project is well-designed, feasible, and integrated with other efforts.

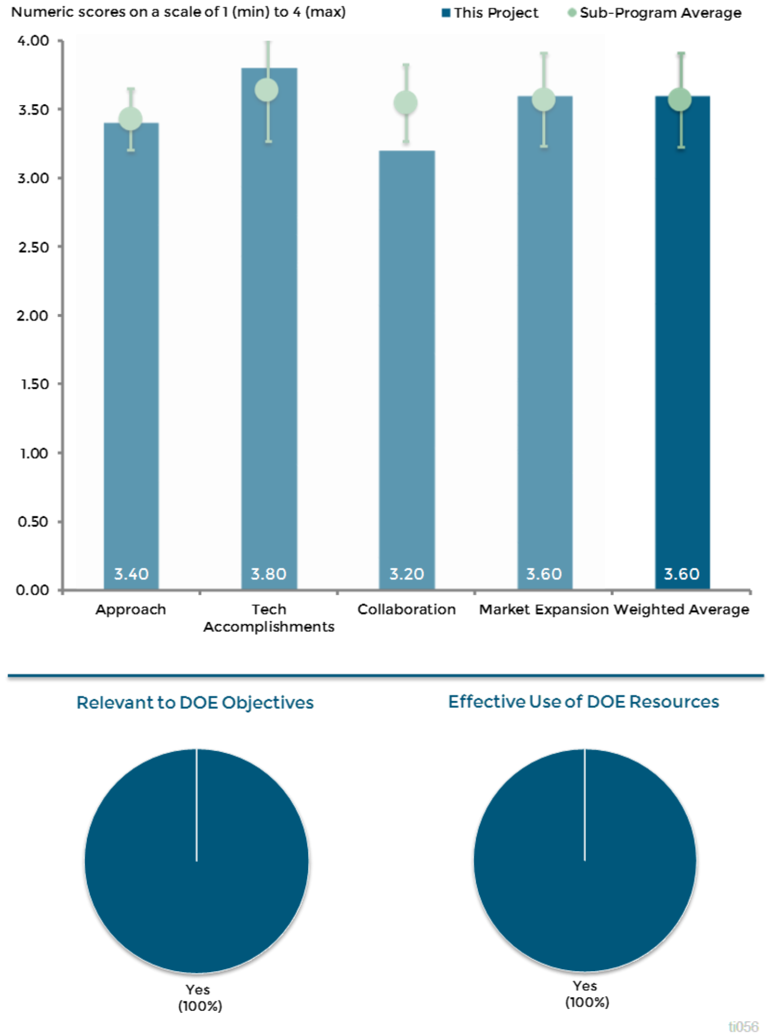


Figure 8-1 Fuel Economy Guide and fueleconomy.gov Website: Bo Saulsbury (Oak Ridge National Laboratory) - Technology Integration

Reviewer 1:

The reviewer asserted that this is a very valuable guide for both consumers and the automotive industry. The reviewer characterized as important the fact that the guide is being shipped to dealers. The reviewer stated that the guide explains the miles per gallon equivalent (MPG$_e$) information, which is helpful. Finally, the reviewer commented that the used car label is a huge benefit to the used car industry and noted that it is downloadable.

Reviewer 2:

The reviewer stated that this project aligns well with and seems to exceed DOE's mandate to provide fuel economy education to consumers. The reviewer concluded that the overall project approach and its various prongs will help consumers make more fuel-efficient decisions and allay their potential concerns about the trustworthiness of MPGE ratings.

Reviewer 3:

The reviewer stated that the project approach section provides effective methodology to accomplishing the project objectives for fiscal year (FY) 2014 and FY 2015. The reviewer also stated that adequate detail is provided on the approach and milestone slides with regards to the planned tasks and activities.

Reviewer 4:

The reviewer praised the information provided through project activities as exceptional, and cautioned that there seems to be a lesser emphasis on alternative fuels information versus conventional vehicle fuel economy information.

The reviewer recommended a closer look at the user experience and taking into consideration that there is an enormous amount of information that could very quickly turn the user away, for lack of knowing where to begin.

The reviewer also praised the media approach effort, stating that it is a great way to get the program acknowledged, in particular through the planned public service ad campaign.

Reviewer 5:

The reviewer observed that the project continues to maintain clear and robust alternative fuel MPGE ratings for flex-fuel vehicles and other AFVs on fuel economy (FE) window stickers, the Fuel Economy Guide (FEG), and website.

The reviewer pointed out that, while the FEG website includes a "Safety" tab, in many cases, only a link to National Highway Traffic Safety Administration (NHTSA) is provided. The reviewer suggested that these tabs should be pre-populated with crash test rating information. Furthermore, the reviewer commented that there is an opportunity for the FEG to highlight vehicles that achieve both high crashworthiness/safety ratings in addition to strong fuel economy. The reviewer observed that there are many fuel-efficient cars that also achieve a strong safety rating and that highlighting these vehicles could help dispel a common consumer misconception that one needs a large vehicle (truck/sport utility vehicle (SUV)) in order to stay safe on the road. The reviewer concluded that an integrated view of safety and efficiency could be especially useful to consumers.

Question 2: Project Accomplishments and Progress toward overall project and DOE goals—the degree to which progress/significant accomplishments have been achieved, measured against performance indicators and demonstrated progress toward project and DOE goals.

Reviewer 1:

The reviewer observed an excellent tool to provide resources for Clean Cities coordinators, and noted that it does effectively include electric vehicles (EVs). The reviewer stated that the trip calculator is excellent. The reviewer also praised the gas savings research on technologies as an excellent resource. The reviewer suggested that the project team do a deep dive presentation to Clean Cities coordinators at the next coordinator summit.

Reviewer 2:

The reviewer praised the project's website statistics and hits as very impressive and a testament to the fact that the project team can keep information on the site updated, timely, and accurate.

Reviewer 3:

The reviewer stated that significant progress has been made towards achieving FY 2014 and FY 2015 project goals and that all initiatives and activities appear to be on track for successful completion. The reviewer observed that the activities to upgrade existing tools/develop new tools for the fueleconomy.gov website should continue to provide end-users with various options to better help make an informed vehicle purchase decision. The reviewer said no concerns have been identified.

Reviewer 4:

The reviewer praised the project as having achieved a very useful modernization of both the FEG and website across multiple technology platforms that have kept both highly accessible and user-friendly to consumers. The reviewer stated that inclusion of driving range for plug-in hybrid electric vehicles (PHEVs) and EVs is a valuable addition to the FE vehicle sticker.

Reviewer 5:

The reviewer described the project work accomplished as significant and well developed, with a tremendous amount of excellent information and tools made available. The reviewer stated that the website obviously has the most potential for impact, and praised the program management as doing a wonderful job with staying on top of new web technology and keeping the website compliant. The reviewer expressed a concern that the users could become overwhelmed with so much information when first entering the website. The reviewer suggested a simpler user interface as a way to prevent this and a "start here" link that would allow users to simply assess what the site offers and what direction they should go on the site to gather the information needed.

Question 3: Collaboration and Coordination among Project Team—the degree to which the appropriate team members and partners are involved in the project work and the effectiveness of the collaboration between and among partners.

Reviewer 1:

The reviewer stated there was an effective project team assembled to carry out this project with numerous government and industry partners involved. The reviewer also characterized the roles of the project team as well defined and said that the collaboration and communication among project partners appears to be appropriate for the project of this scope.

Reviewer 2:

The reviewer said that the project team is doing a nice job in distribution of material to dealerships. The reviewer suggested that Clean Cities Coalition coordinators receive a communication alerting them to when dealers get the guide. The reviewer concluded that the project team has provided evidence of good collaboration to get the job done.

Reviewer 3:

The reviewer described the project as involving good collaboration but suggested that given the excellent information on alternative fuels provided by the Alternative Fuels Data Center (AFDC), perhaps there could be stronger collaboration with that project team. The reviewer stated that this would allow for cross-use of more alternative fuels data that would help in strengthening the alternative fuels information provided through this project.

Reviewer 4:

The reviewer stated that it might be interesting to see some more targeted collaboration with dealerships, with consumer groups that can help spread the word, and with fleet decision makers.

Reviewer 5:

The reviewer remarked that there is an opportunity and need for greater vehicle dealer outreach and training on the FEG and website (beyond just guide dissemination).

Question 4: Alternative Fuel Market Expansion and/or Petroleum Reduction Potential—the degree to which the project has the potential to contribute to a sustainable alternative fuel vehicle market and/or reduce petroleum dependence in the transportation sector, including the potential to reduce barriers to large scale alternative fuel vehicle market penetration and make information about alternative fuels and petroleum reduction opportunities widely available to target audiences.

Reviewer 1:

The reviewer praised the tools as excellent ones to accomplish both market expansion and petroleum reduction.

Reviewer 2:

The reviewer stated that the focus of this project (i.e., consumer education) is vitally important to DOE's efforts to reduce petroleum use in the transportation sector.

Reviewer 3:

The reviewer stated that the project absolutely has a huge potential to contribute to the alternative fuel vehicle market expansion, but added that the contribution could be much more by enhancing the user experience with a simplified web user interface. The reviewer summarized that the information is on the website and just needs to be presented in a more user friendly way to draw in more users and provide them with easy to find, useful information on their visits.

Reviewer 4:

The reviewer suggested that the current methodology estimating FEG impact on petroleum consumption could perhaps be improved (for example, by linking fueleconomy.gov visits to actual vehicle sales data, consumer surveys, etc.). The reviewer also stated that proposed efforts to engage other online vehicle sales sites/vendors (e.g., eBay, CarMax, etc.) would be important and valuable for future project work.

Reviewer 5:

The reviewer stated that the project should contribute to reduced petroleum dependence in the transportation sector, as well as contribute to a sustainable alternative fuel vehicle market, through the activities accomplished to date and the completion of the remaining project activities. The reviewer said noteworthy activities that should contribute are the continued refinement of the “Find and Compare Cars,” “Gas Mileage Tips,” and the “Hybrid & PHEV calculator” tools.

Question 5: Relevance: Does this project support the overall DOE objectives of reducing reliance on petroleum based fuels?

Reviewer 1:

The reviewer praised the FEG and website as providing credible, fundamental public information that is highly important in guiding consumers’ decisions about energy and vehicle transportation choices. The reviewer declared that the public and consumer value of the FEG cannot be overstated.

Reviewer 2:

The reviewer stated that the project relevance slides clearly describe the project’s statutory requirements, as well as how the project addresses specific barriers in the VTO’s Multi-Year Program Plan 2011-2015.

Reviewer 3:

The reviewer agreed that the goal of this project (i.e., to reduce petroleum based fuels through fuel economy and the use of alternative fuel vehicles) definitely supports DOE objectives of reducing reliance on petroleum based fuels.

Reviewer 4:

The reviewer stated that although the specific metrics are hard to capture (i.e., it is unknown exactly how much petroleum dependence has been reduced as a result of this project), the FEG and website clearly help consumers make important decisions about their purchases, and they seem to be helping consumers understand the benefits of fuel efficiency and how it works.

Reviewer 5:

Considering the petroleum reduction goal, this reviewer explained the importance of understanding what actually happens for MPG_e in the transportation sector and how the tools provided enable consumers to make a valid choice to reduce fuel use.

Question 6: Comments on Use of Resources.

Reviewer 1:

The reviewer observed that fueleconomy.gov activities fulfill DOE’s statutory responsibility to provide fuel economy information to the public (49 U.S.C. 32908, 2006) and therefore must continue to be funded. The reviewer characterized the activities related to developing and improving tools for the public to make informed vehicle purchase decisions, based on either fuel economy and/or greenhouse gas (GHG) reduction comparisons, as critical in reaching mass audiences (versus a fleet focus). Additionally, the reviewer stated it is important to continue to link FE.Gov to the AFDC to provide more detail on alternative fuel and advanced technology vehicles available for sale.

Reviewer 2:

The reviewer stated that this is a wise use of DOE funds and should continue into the future.

Reviewer 3:

The reviewer characterized the project as a good use of resources to get the petroleum reduction method out the door to consumers and fleet managers.

Reviewer 4:

The reviewer commented that the project is very important and needed. The reviewer stated that the tools being developed are quite labor intensive and justifies the funding and that project efforts are worthy of continued funding. The reviewer recommended a better collaboration with AFDC and cross utilization of the information and materials developed through that program to avoid the funding of some of the same data for both sites. The reviewers suggested that a $350,000 outreach/marketing budget should bring significant program impact/recognition.

Fuel Economy Information Project - Research, Data Validation, and Technical Assistance Related to Collecting, Analyzing, and Disseminating Accurate Fuel Economy Information: Bo Saulsbury (Oak Ridge National Laboratory) - ti057

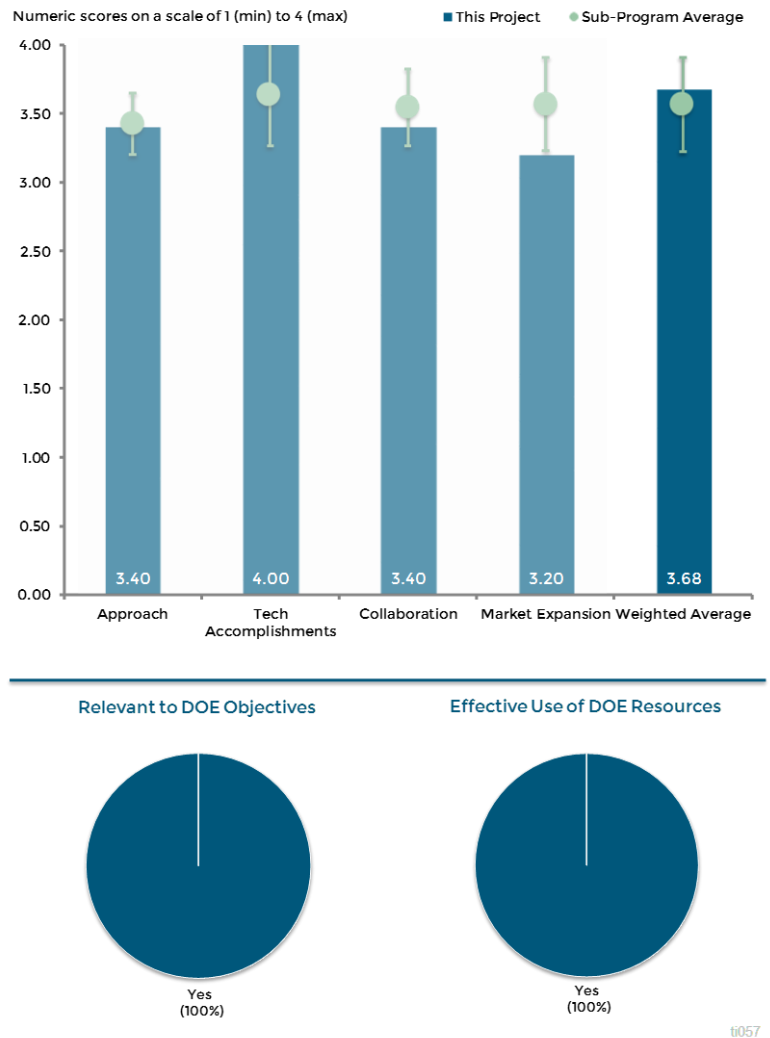


Figure 8-2 Fuel Economy Information Project - Research, Data Validation, and Technical Assistance Related to Collecting, Analyzing, and Disseminating Accurate Fuel Economy Information: Bo Saulsbury (Oak Ridge National Laboratory) - Technology Integration

Presenter

Brian West, Oak Ridge National Laboratory.

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Project Approach to supporting deployment of petroleum reduction technologies and practices, alternative fuel vehicles, infrastructure and related efforts—the degree to which the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer commented that this project has done an excellent job of providing detailed, customized, and usable information to vehicle purchasers.

Reviewer 2:

The reviewer characterized the project approach section as providing effective methodology to accomplishing the project objectives for FY 2014 and FY 2015. The reviewer stated that adequate detail is provided on the approach and milestone slides with regards to the planned tasks and activities.

Reviewer 3:

The reviewer described the information and research that is done as reasonably well focused on the consumer. The reviewer recommends that a fleet corner be added to some of the material.

Reviewer 4:

The reviewer stated that the project approach is sound, producing consumer-focused research that adds notable value to the FEG website.

The reviewer observed that there is a wide array of after-market devices and automotive lubricants in existence that claim to boost vehicle fuel economy and suggested that research into some of these consumer-targeted products, to validate or dispute their claims, would be beneficial. The reviewer commented that it can be hard for consumers to discern which products may be gimmicks and/or snake-oil. The reviewer also noted that the project team plans to research several additional good topics useful to the consumer such as vehicle accessory loads (electronics, heated seats), pre-heating vehicle in winter, etc.

Reviewer 5:

The reviewer described the project approach as very strong and remarked that consumer information/education is critical. The reviewer stated that the only obvious weakness is that alternative fuel vehicle information seems to take second place to conventional vehicle fuel economy information. The reviewer concluded that it is obvious there is an abundance of research and project data gathered/developed and suggested a poll or survey of consumers and industry to ask what information or tools they would like to see developed. The reviewer said that Clean Cities coordinators should be a part of the survey group to ensure tools support their local efforts as well.

Question 2: Project Accomplishments and Progress toward overall project and DOE goals—the degree to which progress/significant accomplishments have been achieved, measured against performance indicators and demonstrated progress toward project and DOE goals.

Reviewer 1:

The reviewer remarked that the research and data collected, as well as the validation of data, appear to be excellent and of significant quantity, resulting in great consumer information and tools. The reviewer also stated that the project did an excellent job on the process of taking technical information and turning it into consumer friendly information.

Reviewer 2:

The reviewer stated that significant progress has been made towards achieving FY 2014 and FY 2015 project goals. The reviewer also stated that all initiatives and activities appear to be on track for successful completion and commented that activities such as validating existing/adding new fuel efficiency tips (i.e., for hybrid electric vehicles (HEVs), plug-in electric vehicles (PEVs), EVs, cold/warm weather driving, effects of speed, effects of vehicle alterations, etc.) should continue to provide the general public information on how to maximize their driving efficiency and reduce the amount of petroleum used. The reviewer said no concerns have been identified.

Reviewer 3:

The reviewer stated that the completed special research activities studying the impact of various vehicle operations and/or features (such as air conditioning use, air filter maintenance, speed, hitched trailers and other myth-buster topics) are very valuable to the public.

The reviewer described the consumer information page on fuel octane as concise and a very useful addition to the site and suggested that additional similar information pages on ethanol/ethanol blends would also be beneficial (if they do not already exist).

Reviewer 4:

The reviewer noted there was fuel reduction information and thanked the project for the octane rating. The reviewer asked if the project fed information about tire fuel economy to tire sales stores, and suggested looping in tire dealers about the fuel reductions that can be achieved with proper tires and maintenance.

Question 3: Collaboration and Coordination among Project Team—the degree to which the appropriate team members and partners are involved in the project work and the effectiveness of the collaboration between and among partners.

Reviewer 1:

The reviewer stated there was an effective project team assembled to carry out this project, with numerous government and industry partners involved. The reviewer said the roles of the project team are well defined and collaboration/communication among project partners appears to be appropriate for the project of this scope.

Reviewer 2:

The reviewer praised the nice job done of collaborating with the automotive industry.

Reviewer 3:

The reviewer recommended a stronger collaboration with the Alternative Fuels Data Center (AFDC) team to cross-utilize alternative fuel vehicle data, so that alternative fuel vehicle information can be better portrayed overall throughout project materials.

Reviewer 4:

The reviewer said that although the project team is very well-qualified, it seems very focused on the laboratories and academia. The reviewer suggested that more engagement with consumer groups, Clean Cities coalitions, or other channels to access potential vehicle consumers may benefit the project.

Reviewer 5:

The reviewer said that while current industry and stakeholder coordination is good, it is nevertheless a bit ad-hoc. The reviewer suggested that some increased formality in terms of stakeholder input to the FE project may be beneficial (e.g., a more established advisory body structure, documentation of external participant inputs, etc.).

Question 4: Alternative Fuel Market Expansion and/or Petroleum Reduction Potential—the degree to which the project has the potential to contribute to a sustainable alternative fuel vehicle market and/or reduce petroleum dependence in the transportation sector, including the potential to reduce barriers to large scale alternative fuel vehicle market penetration and make information about alternative fuels and petroleum reduction opportunities widely available to target audiences.

Reviewer 1:

The reviewer praised the practical real time research that has been accomplished in this program as outstanding. The reviewer described the project’s great tools for Clean Cities coalition coordinators as they push for fuel reduction in the transportation sector.

Reviewer 2:

The reviewer remarked that the research and data collected, as well as the overall technical support with media and general questions, serve a very important role in helping to educate consumers and other audiences in making better clean transportation choices.

Reviewer 3:

The reviewer praised the My MPG pages as great. The reviewer said that a potentially significant enhancement to My MPG would be direct marketing or targeting of tips to My MPG users that are reporting low fuel economy. The reviewer suggested that Clean Cities coordinators could help in delivering targeted messaging or tips.

Reviewer 4:

The reviewer stated that the project should contribute to reduced petroleum dependence in the transportation sector, as well as contribute to a sustainable alternative fuel vehicle market, through the activities accomplished to date and the completion of the remaining project activities. The reviewer said noteworthy activities that should contribute are the continued refinement/addition of fuel efficient driving and maintenance tips.

Reviewer 5:

The reviewer remarked that the project presentation did not specifically address this criterion. The reviewer suggested that user statistics for the My MPG pages, in addition to other fueleconomy.gov traffic data may help provide a baseline for better addressing this criterion in future reviews.

Question 5: Relevance: Does this project support the overall DOE objectives of reducing reliance on petroleum based fuels?

Reviewer 1:

The reviewer praised the project as providing timely, responsive, and informative research to help consumers achieve greater fuel economy and petroleum reduction.

Reviewer 2:

The reviewer described the project as helping inform consumers, who ultimately hold decision-making power about their purchases. The reviewer said that by presenting information in a user-friendly way, this project creates more informed consumers and helps draw attention to fuel-efficient and AFVs that might not have otherwise happened in its absence.

Reviewer 3:

The reviewer agreed that this project supports the overall DOE objectives of reducing reliance on petroleum based fuels by providing consumers and other audiences with much needed information to help with their purchasing decisions of fuel economy/AFVs.

Reviewer 4:

The reviewer stated that the Project Relevance slides clearly describe the project’s statutory requirements, as well as how the project addresses specific barriers in the VTO’s Multi-Year Program Plan 2011-2015. The reviewer concluded that the activities related to developing/improving tools and resources for the public to adopt more fuel efficient driving practices will help contribute to reducing our nation’s petroleum consumption.

Reviewer 5:

The reviewer emphasized tools and research as the best ammunition for fuel reduction strategies.

Question 6: Comments on Use of Resources.

Reviewer 1:

The reviewer characterized the project as absolutely a good use of resources.

Reviewer 2:

The reviewer said the project seems to be a necessary and valuable use of DOE resources.

Reviewer 3:

The reviewer stated that fueleconomy.gov activities fulfill DOE’s statutory responsibility to provide fuel economy information to the public (49 U.S.C. 32908, 2006) and therefore must continue to be funded. The reviewer also stated that activities related to developing/improving tools and resources for the public to adopt more fuel efficient driving practices will help contribute to reducing the nation’s petroleum consumption.

Reviewer 4:

The reviewer agreed that the amount of work conducted for the budget appears to be good. The reviewer characterized the $375,000 marketing budget as allowing for significant publication/impact of project. However, the reviewer cautioned that there is not enough information to validate this part of the budget, although there is some mention of media impact. The reviewer concluded that project efforts are worthy of continued funding.

Alternative Fuel Station Locator: Andrew Hudgins (National Renewable Energy Laboratory) - ti058

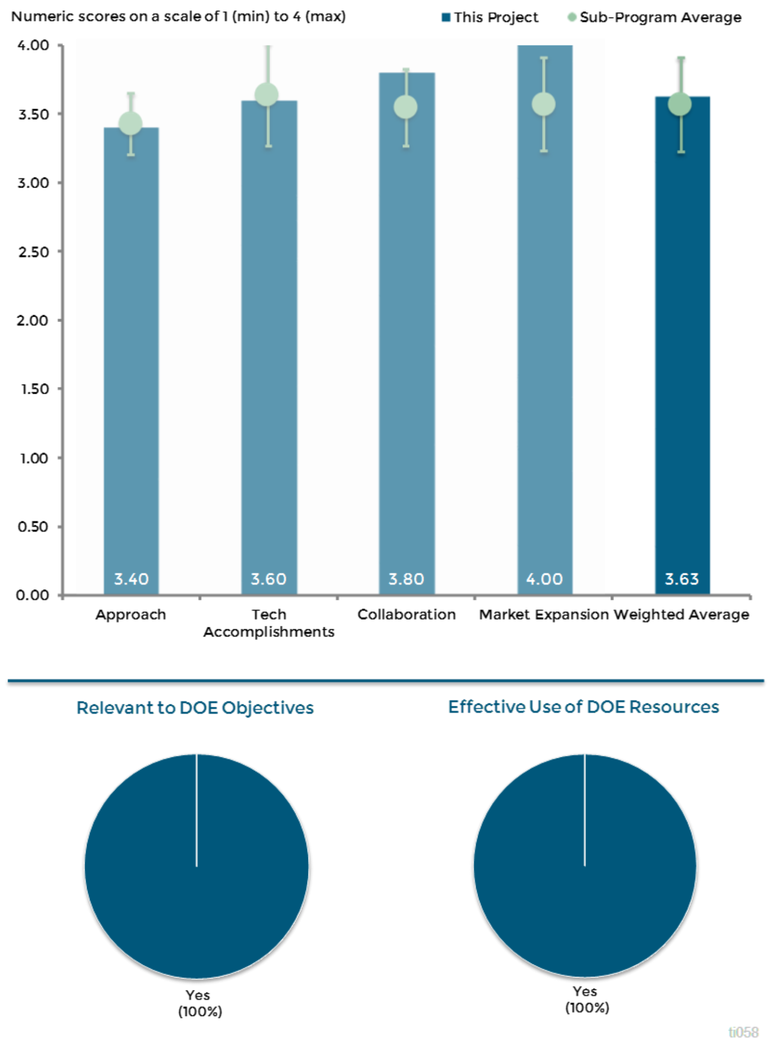


Figure 8-3 Alternative Fuel Station Locator: Andrew Hudgins (National Renewable Energy Laboratory) - Technology Integration

Presenter

Andrew Hudgins, National Renewable Energy Laboratory.

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Project Approach to supporting deployment of petroleum reduction technologies and practices, alternative fuel vehicles, infrastructure and related efforts—the degree to which the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer noted that it is not possible to reduce conventional fuel use without the use of alternative fuels and that alternative fuel cannot be used if the stations cannot be found. The reviewer praised the project as a nation leading tool.

Reviewer 2:

The reviewer praised the project approach section as providing effective methodology to accomplishing the project objectives for FY 2014 and FY 2015 and said that adequate detail is provided on the approach and milestone slides with regards to the planned tasks and activities.

Reviewer 3:

The reviewer stated that the project approach is integrated and supports the overall objectives of the program's goals. However, the reviewer pointed out that how stations are evaluated for being open varies, noting that sometimes an open station can be interpreted differently depending on which alternative fuel is being discussed.

Reviewer 4:

The reviewer praised the project team as having developed an efficient data collection and management approach for maintaining a robust alternative fuel station database.

The reviewer pointed out that overlapping regional/metropolitan AFV concentrations with the station locator map would help identify infrastructure gaps and where potential unmet fuel markets exist (e.g., ethanol 85 (E85) and flexible-fuel vehicles (FFVs)). The reviewer suggested that this could serve as a good extension of the tool, especially useful to station developers, researchers, and other stakeholders.

Reviewer 5:

The reviewer characterized the ability to now make real-time changes as critical, as the market is changing rapidly. The reviewer cautioned that the once-per-year data checking may not be often enough to catch stations going offline, because these are not as likely to be reported as those coming online. The reviewer was glad to hear that hydrogen stations will be included in the graph showing the total stations by this time next year. The reviewer suggested that for future work it may be good to define what open means. The reviewer inquired as to whether open means commercial, or whether there needs to be an agreement with the station owner/operator.

Question 2: Project Accomplishments and Progress toward overall project and DOE goals—the degree to which progress/significant accomplishments have been achieved, measured against performance indicators and demonstrated progress toward project and DOE goals.

Reviewer 1:

The reviewer remarked that because it is the only truly all-encompassing alternative fuel locator, this tool is very important to alternative fuel users. The reviewer offered a bravo to this group that has sped up the time to list EVSE stations as they are installed.

Reviewer 2:

The reviewer characterized as very useful the tool enhancements that enable greater fuel station search refinement (e.g., ethanol by blend level, natural gas (NG) by pressure, EVSE by charger type, etc.).

Reviewer 3:

The reviewer praised the project team as showing good education and outreach, resulting in a 31% increase in web submissions in 2014 over 2013.

Reviewer 4:

The reviewer stated that significant progress has been made towards achieving FY 2014 and FY 2015 project goals. The reviewer also stated that all initiatives and activities appear to be on track for successful completion. The reviewer offered that the expanded industry outreach and collaboration should continue to ensure up-to-date and accurate station data is provided for vehicle operators that rely on the Station Locator.

Reviewer 5:

The reviewer stated that the project produces a lot of good data and tracks the number of page views and hits on a daily basis but noted that this is a very difficult metric to correlate to impact. This reviewer cautioned that this can be difficult based on the nature of the project.

Question 3: Collaboration and Coordination among Project Team—the degree to which the appropriate team members and partners are involved in the project work and the effectiveness of the collaboration between and among partners.

Reviewer 1:

The reviewer praised the excellent project team assembled to carry out this project with numerous public and private entities involved. The reviewer also emphasized that collaboration and communication among project partners appears to be one of the major strengths of this activity.

Reviewer 2:

The reviewer praised the collaboration and coordination as the strongest portion of the project. The reviewer noted that without strong collaboration and coordination, the project objectives would be more difficult to achieve.

Reviewer 3:

The reviewer characterized the project team as a good one. The reviewer described as very helpful the fact that the project team reaches out to all the alternative fuel associations. The reviewer mentioned that the project team has developed a relationship with U-Haul and described it as great. The reviewer applauded the liquefied petroleum gas (LPG) station concept as a good one. Finally, the reviewer observed an excellent job in pushing the autogas market to accommodate vehicles.

Reviewer 4:

The reviewer characterized it as a very large collaboration and good two-way sharing to ensure other databases are also up-to-date.

Reviewer 5:

The reviewer stated that the project demonstrates robust industry collaboration and coordination in cultivating and vetting station info (Renewable Fuels Association (RFA), General Motors, and NGVAmerica, etc.).

The reviewer described the project team's previous outreach and dialogue with Google as proactive. The reviewer characterized the current strategy of steering other geographic information providers to the DOE station locator tool as good, and efforts to leverage google-based image/map data as sound. The reviewer recommended that further integration of station data with Google maps in the future is something the team should continue to explore.

Question 4: Alternative Fuel Market Expansion and/or Petroleum Reduction Potential—the degree to which the project has the potential to contribute to a sustainable alternative fuel vehicle market and/or reduce petroleum dependence in the transportation sector, including the potential to reduce barriers to large scale alternative fuel vehicle market penetration and make information about alternative fuels and petroleum reduction opportunities widely available to target audiences.

Reviewer 1:

The reviewer described this tool as very useful to alternative fuel market development.

Reviewer 2:

The reviewer characterized the database as critical to encourage consumer purchases of AFVs. The reviewer remarked that review of the federal fleet data showing missed opportunities is an excellent way to identify low hanging fruit for additional petroleum reduction. The reviewer also acknowledged the benefit to developers who can look at the map to see where there are gaps in coverage, determine where they might want to develop stations to fill those gaps, and see what the incentives are in those states/districts. Finally, the reviewer noted that the tool can also be used to track how the incentives impact the build-out of the stations over time and described this as very beneficial in showing the impact of policy.

Reviewer 3:

The reviewer described the locator tool as providing a critical service and fundamental information necessary for enabling consumers and fleets to access and use alternative fuels. The reviewer suggested that it would be particularly useful if the tool captured statistics on station use/fuel volumes dispensed.

Reviewer 4:

The reviewer stated that the project should contribute to local/regional alternative fuel market expansion, through the completion of the remaining project activities. The reviewer stated that noteworthy activities that should contribute are the continued outreach to Clean Cities Coordinators, coordination with DOE programs, and industry collaborations.

Question 5: Relevance: Does this project support the overall DOE objectives of reducing reliance on petroleum based fuels?

Reviewer 1:

The reviewer said this project absolutely has potential for alternative fuel market expansion and petroleum reduction.

Reviewer 2:

The reviewer described this project as supporting the DOE objectives of petroleum displacement by reducing barriers associated with the availability of alternative fuels and electric charging infrastructure. The reviewer stated that by providing fleet managers, drivers and consumers with a comprehensive list of fueling stations and options, this will help to facilitate the greater adoption of alternative and advance vehicle technologies.

Reviewer 3:

The reviewer stated that the use of statistics shows that a sizeable number of people are using the station locator tool to locate where to purchase alternative fuels.

Reviewer 4:

The reviewer remarked that in order to reduce the use of petroleum based fuels, it is critical that consumers can easily access data on where alternatives are available.

Question 6: Comments on Use of Resources.

Reviewer 1:

The reviewer remarked that in lieu of funding for hardware (i.e., vehicles and fueling sites), the use of DOE funding to inform the public about the availability of the existing alternative fuel and electric charging infrastructure is critically important. The reviewer also stated that understanding the availability of the existing fueling options in a fleet's area/region is absolutely necessary to develop a successful deployment strategy. The reviewer offered that if a more significant level of funding were to become available in the future, these activities combined with funding for hardware would be the preferred strategy for targeted market expansion.

Reviewer 2:

The reviewer declared that this is a must-have tool, so funding this is imperative.

Reviewer 3:

The reviewer stated that it is important that all alternative fuels – particularly those for commercial vehicles – are captured. The reviewer remarked that the plan to incorporate hydrogen going forward is critical for successful deployment of zero-emission vehicles (ZEVs) which use fuel cell (FC) technology.

Alternative Fuels Data Center and API: Johanna Levene (National Renewable Energy Laboratory) - ti059

Presenter

Johanna Levene, National Renewable Energy Laboratory.

Reviewer Sample Size

A total of five reviewers evaluated this project.

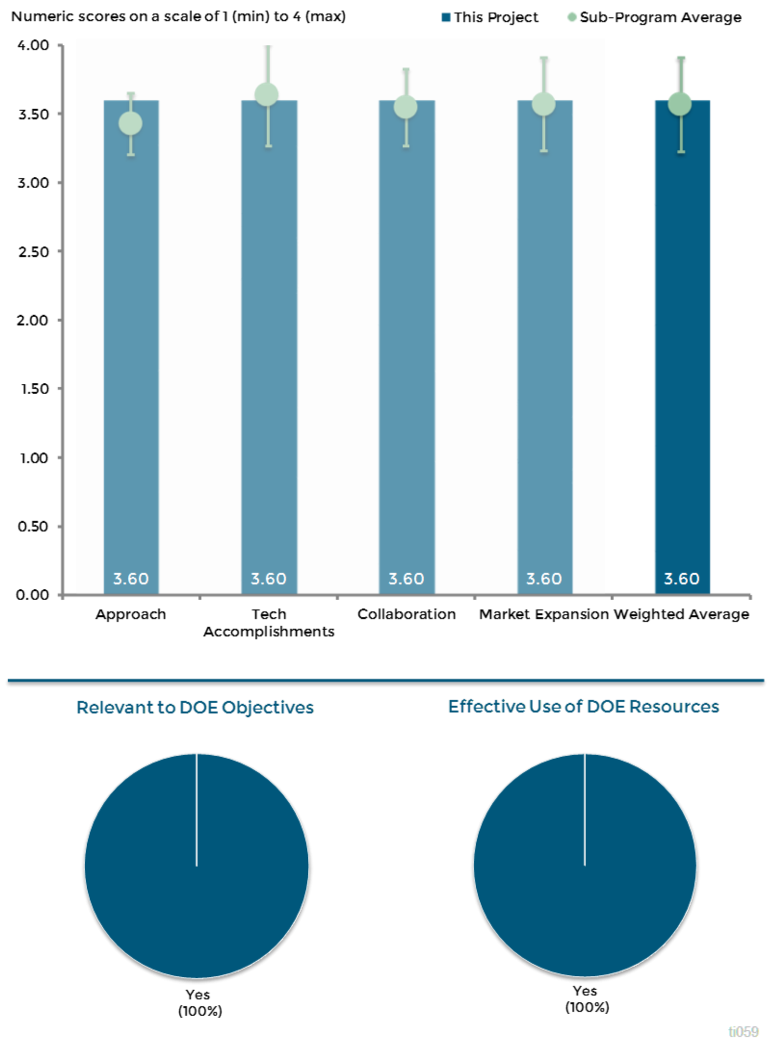


Figure 8-4 Alternative Fuels Data Center and API: Johanna Levene (National Renewable Energy Laboratory) - Technology Integration

Question 1: Project Approach to supporting deployment of petroleum reduction technologies and practices, alternative fuel vehicles, infrastructure and related efforts—the degree to which the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer characterized the project's approach to supporting alternative fuel research by significantly enabling increased data sharing of AFDC-hosted information as excellent. The reviewer also characterized hotspot market analysis drawing on data extracted from the Application Programming Interface (API)/station locator tool as a good example of how the project's approach advances alternative fuel research.

Reviewer 2:

The reviewer remarked that all the data on the sites that has been evaluated is available thanks to the diligence of this team and added that in today's technical world, APIs are very important.

Reviewer 3:

The reviewer praised the project approach section as providing an effective methodology for accomplishing the project objectives for FY 2014 and FY 2015, for both the AFDC and AFDC APIs. The reviewer stated that the approach and milestone slides have adequate detail with regards to the planned tasks and activities.

Reviewer 4:

The reviewer praised the project's approach as nice overall. The reviewer suggested tracking gasoline prices and total page views along with alternative fuel price, if possible, adding that this could also lead to additional helpful information.

Reviewer 5:

The reviewer described the focus on fleets as interesting but would like to see more information on the commercial light-duty vehicle (LDV) market as well. The reviewer praised the widget as great for easy integration into other websites and said that having multiple ways to access the data is a good approach.

Question 2: Project Accomplishments and Progress toward overall project and DOE goals—the degree to which progress/significant accomplishments have been achieved, measured against performance indicators and demonstrated progress toward project and DOE goals.

Reviewer 1:

The reviewer described accomplishments and progress made by the project team as nice.

Reviewer 2:

The reviewer characterized the project as conducting work that is very responsive to both consumer and program needs (e.g., gaseous fuel temperature/pressure tool addresses a key consumer acceptance/market barrier).

The reviewer praised the project as very comprehensive in its data sharing tasks and noted that substantially increased API requests have allowed AFDC data to touch many places and be incorporated in a wide array of external tools, research products, and communication platforms.

Reviewer 3:

The reviewer remarked that the project group has a difficult task staying ahead of requests for data, yet handles it superbly, with requests met in a timely manner.

Reviewer 4:

The reviewer noted that the significant use of the project data shows the value of the project.

Reviewer 5:

The reviewer observed that significant progress has been made towards achieving FY 2014 and FY 2015 project goals and stated that all initiatives and activities appear to be on track for successful completion. The reviewer noted that the continued growth in number of AFDC views, as well as the fact that AFDC has approximately 25% of all the Office of Energy Efficiency and Renewable Energy (EERE) webpage views illustrates the importance of the site as a comprehensive unbiased clearinghouse of information about alternative fuels and advanced vehicles technologies for fleets, industry, and the general public. The reviewer added that the expanded use of AFDC APIs will ensure that the data collected by DOE will be shared and will assist end-users in enhancing their own sites, analyses and tools.

Question 3: Collaboration and Coordination among Project Team—the degree to which the appropriate team members and partners are involved in the project work and the effectiveness of the collaboration between and among partners.

Reviewer 1:

The reviewer remarked that this project demonstrates strong coordination with other DOE programs and analysis tools.

Reviewer 2:

The reviewer praised the great collaboration and coordination among the project team.

Reviewer 3:

The reviewer commented on the effective project team assembled to carry out this project, with numerous DOE national laboratories and EERE transportation related programs involved. The reviewer said collaboration among project partners appears to be appropriate for the project of this scope.

Reviewer 4:
The reviewer described the good collaboration with Idaho National Laboratory (INL).

Reviewer 5:
The reviewer described as good progress reaching out to the Energy Information Administration (EIA). The reviewer noted that the project team must work with the other DOE technical folks such as the National Renewable Energy Laboratory (NREL) and Argonne National Laboratory to make things happen and added that they do a nice job collaborating.

Question 4: Alternative Fuel Market Expansion and/or Petroleum Reduction Potential—the degree to which the project has the potential to contribute to a sustainable alternative fuel vehicle market and/or reduce petroleum dependence in the transportation sector, including the potential to reduce barriers to large scale alternative fuel vehicle market penetration and make information about alternative fuels and petroleum reduction opportunities widely available to target audiences.

Reviewer 1:
The reviewer remarked that all the reports and data made available through this service further increase the ability of folks to continue the fuel reduction strategies that are needed for additional petroleum reductions.

Reviewer 2:
The reviewer stated that data accessibility is important to expand the alternative fuels market. The reviewer also observed that the ability to use the data to determine which station types and locations are most popular is very interesting in terms of looking at policies and adoption rates in different areas.

Reviewer 3:
The reviewer stated that the project should contribute to local/regional alternative fuel market expansion, through the completion of the remaining project activities. The reviewer also stated that noteworthy activities that should contribute are the continued collaboration with key audiences such as fleets, industry partners, Clean Cities coordinators, and government programs to expand the alternative fuels market.

Reviewer 4:
The reviewer remarked that project presentation did not specifically address this criterion (alternative fuel market expansion and petroleum reduction potential). However, the reviewer stated it is clear that the project contributes immensely to the body of knowledge around alternative fuel and advanced vehicle technologies and markets, which in turn supports deployment.

Question 5: Relevance: Does this project support the overall DOE objectives of reducing reliance on petroleum based fuels?

Reviewer 1:
The reviewer commented that the project is directly supportive of DOE’s objectives to reduce reliance on petroleum fuels, advance information sharing and research of alternative fuels and advanced vehicle technologies, and aid technology deployment.

Reviewer 2:
This reviewer stated that project supports the DOE objectives of petroleum displacement by establishing a clearinghouse for information that reduces the barriers to adopting alternative fuel technologies. The reviewer praised the AFDC as offering transportation decision-makers unbiased information, data, and tools related to the deployment of alternative fuels and advanced vehicles. The reviewer observed that the AFDC connects its audience to information and data through a variety of digital channels, increasing exposure to alternative fuels and advanced vehicles.

Reviewer 3:

The reviewer commented yes.

Reviewer 4:

The reviewer stated that data accessibility is important to expand the alternative fuels market.

Question 6: Comments on Use of Resources.

Reviewer 1:

The reviewer commented that the use of DOE funding to establish/maintain/expand the AFDC is critically important and necessary and praised the site as offering transportation decision-makers unbiased information, data, and tools related to the deployment of alternative fuels and advanced vehicles. The reviewer remarked that all of these products are critical for expanding the market acceptance of alternative fuels and advanced vehicles technologies, as well as the development of the supporting fueling infrastructure.

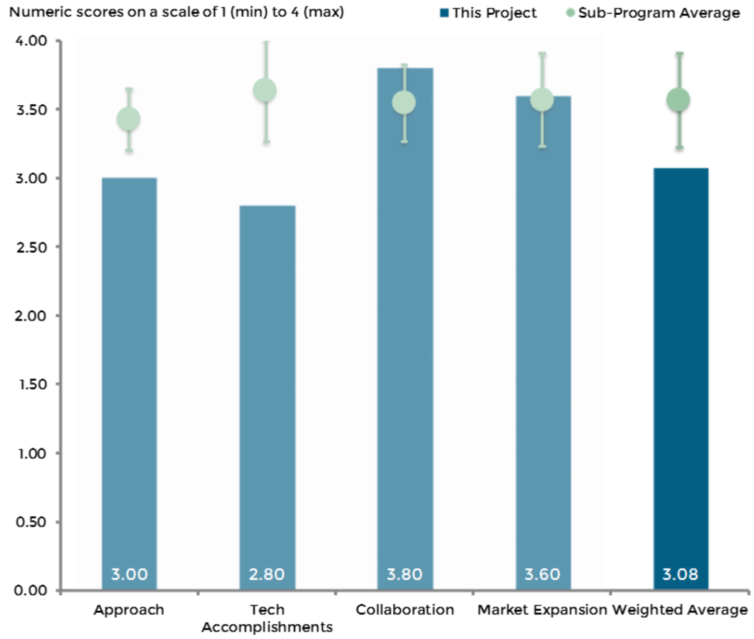
Reviewer 2:

The reviewer observed that the project staff does a lot in this technical environment to provide data at a bargain price, compared to the prices consultants get in the IT space. The reviewer praised the team with a comment of hats off to them.

Reviewer 3:

The reviewer observed that half of the project funding goes toward maintaining the site and the other half toward updates to tools and expanding new tools. The reviewer remarked that it is important to not only maintain existing tools but to adapt to new needs as well and stated that the funding structure takes this into account.

Clean Cities Coordinator Resource Building and National Networking Activities: Wendy Dafoe (National Renewable Energy Laboratory) - ti060



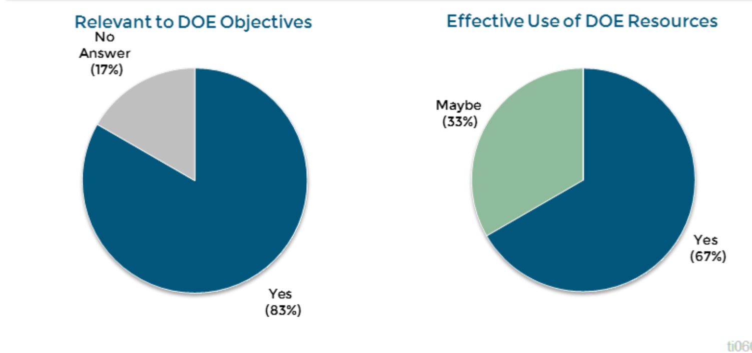


Figure 8-5 Clean Cities Coordinator Resource Building and National Networking Activities: Wendy Dafoe (National Renewable Energy Laboratory) - Technology Integration

Presenter

Wendy Dafoe, National Renewable Energy Laboratory.

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Project Approach to supporting deployment of petroleum reduction technologies and practices, alternative fuel vehicles, infrastructure and related efforts—the degree to which the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer remarked that the approach of training coordinators in each regional area and having mentors is a good way to spread sustainable transportation information.

Reviewer 2:

The reviewer praised the designed approach as providing major pieces of information and resources that meet the needs of a broad based audience. The reviewer remarked that the structure and process seem very clear and on target, and while the focus may be on coordinators and stakeholders, consumers are able to benefit from the project. The reviewer suggested that there be a look into the use of social media to reach more consumers as this would help reduce petroleum use more quickly.

Reviewer 3:

The reviewer remarked that the services offered are fine, but that there needs to be a more proactive way to get the weak coalitions and weak coordinators to ask for them, or, even if they do not ask, somehow get them to avail themselves of the services. The reviewer also expressed a desire to see a more rigorous evaluation system for the mentors.

Reviewer 4:

The reviewer remarked that the 20-minute presentation probably did not highlight the great Clean Cities resource building and national networking enough to really address the impact.

Question 2: Project Accomplishments and Progress toward overall project and DOE goals—the degree to which progress/significant accomplishments have been achieved, measured against performance indicators and demonstrated progress toward project and DOE goals.

Reviewer 1:

The reviewer praised the significant progress toward project goals and objectives, especially in new courses and additional tracks. The reviewer also praised the many webinars highlighted as a strong plus.

Reviewer 2:

The reviewer commented that completing and updating the following items has made for major program progress: online tools; webinars; mentoring programs; Clean Cities University (CCU) programs; Coordinator Toolbox; and one-on-one training. The reviewer added, though, that the one-on-one training needs to be increased. The reviewer remarked that the informal process, or the interaction between the project managers and coordinators, is also playing a significant role in meeting goals.

Reviewer 3:

The reviewer said the presentation is lacking data on what new courses and materials were being offered and noted that statistics to track success were not provided. The reviewer also remarked that the presenter, upon questioning, did not provide information on what courses are offered, or how success is tracked.

Question 3: Collaboration and Coordination among Project Team—the degree to which the appropriate team members and partners are involved in the project work and the effectiveness of the collaboration between and among partners.

Reviewer 1:

The reviewer remarked that there is an incredibly large number of organizations involved and the collaboration is strong.

Reviewer 2:

The reviewer observed a very strong collaborative and coordinated process in place, and believed this is the foundation for the project's success. The reviewer stated that input to support development of the various programs has come from industry, stakeholders, coordinators, and consumers, etc.

Reviewer 3:

The reviewer stated that this could be better.

Question 4: Alternative Fuel Market Expansion and/or Petroleum Reduction Potential—the degree to which the project has the potential to contribute to a sustainable alternative fuel vehicle market and/or reduce petroleum dependence in the transportation sector, including the potential to reduce barriers to large scale alternative fuel vehicle market penetration and make information about alternative fuels and petroleum reduction opportunities widely available to target audiences.

Reviewer 1:

The reviewer remarked that Clean Cities coordination and training is important to support the early markets for alternative fuel vehicles.

Reviewer 2:

The reviewer observed that as issues surface, the project team has moved immediately to address those issues through seminars, webinars, outreach programs, CCU courses, and enhancing the social media program. The reviewer stated that technical support by the project team plays a major role in removing barriers.

Reviewer 3:

The reviewer remarked that the Clean Cities program is the best, although perhaps the only, deployment program that DOE has.

Reviewer 4:

The reviewer posited the question of whether this is really a government role. The reviewer stated that the project should try to get the private sector to look at opportunities to take over the many roles here.

Question 5: Relevance: Does this project support the overall DOE objectives of reducing reliance on petroleum based fuels?

Reviewer 1:

The reviewer praised the tools developed by the project as having helped Clean Cities coordinators and stakeholders build successful strategic plans, to gain buy-in for petroleum reduction programs.

Reviewer 2:

The reviewer remarked that education and outreach are together key components of vehicle adoption.

Question 6: Comments on Use of Resources.

Reviewer 1:

The reviewer stated that future funding is a must. The reviewer also observed that it seems that funding at a level that enables the project team to increase more one-on-one time with coordinators would greatly enhance program outcomes/successes. Additionally, the reviewer remarked that funding support to provide follow-up to gauge mentor's effectiveness would be good for the program.

Reviewer 2:

The reviewer remarked that the Clean Cities coordinators are the feet on the ground, and that giving them tools and education to make them more effective is the best use of the Clean Cities money. The reviewer stated that if there were more money available, it should be partially spent on funding the coordinators.

Reviewer 3:

The reviewer remarked that because the value was not shown in terms of a metric and specifics were not given, it is hard to answer this question.

Reviewer 4:

The reviewer asked if this is this a proper role for DOE or the government in general.

Clean Cities "Tiger Team" Technical and Problem Solving Assistance: John Gonzales (National Renewable Energy Laboratory) - ti061

Presenter

John Gonzales, National Renewable Energy Laboratory.

Reviewer Sample Size

A total of six reviewers evaluated this project.

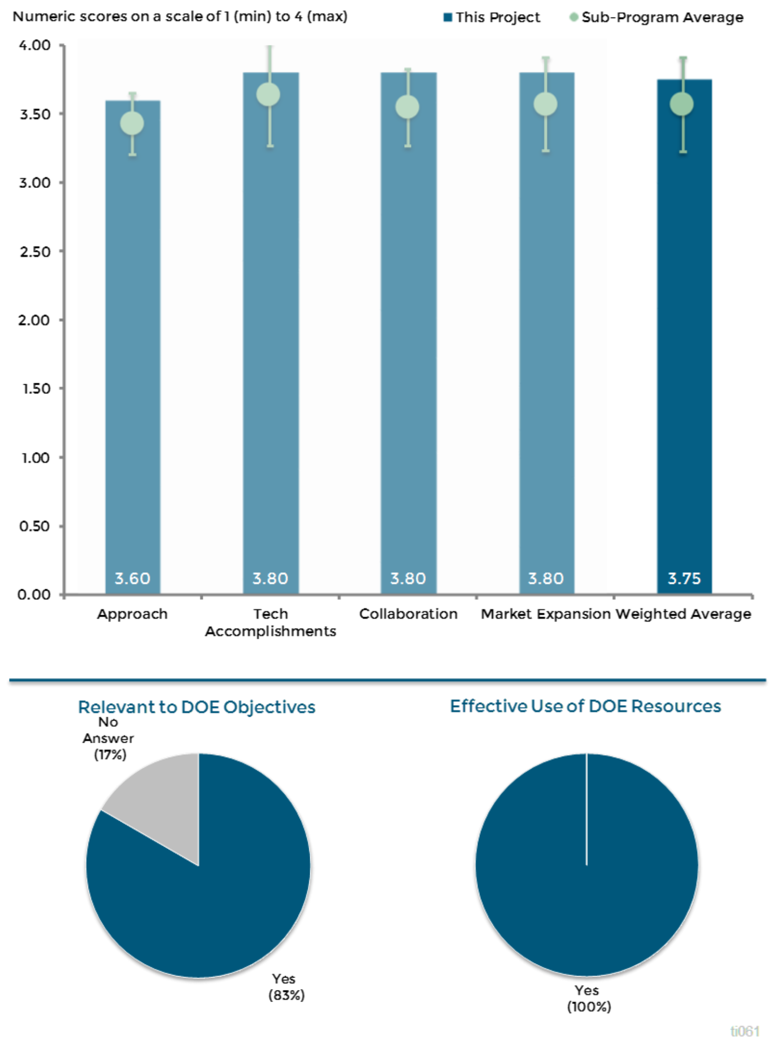


Figure 8-6 Clean Cities "Tiger Team" Technical and Problem Solving Assistance: John Gonzales (National Renewable Energy Laboratory) - Technology Integration

Question 1: Project Approach to supporting deployment of petroleum reduction technologies and practices, alternative fuel vehicles, infrastructure and related efforts—the degree to which the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer remarked that the project takes the right approach with providing technical coordination and guidance to stakeholders to help address barriers and challenges with deployment. The reviewer stated that there could be an opportunity to leverage activities in other areas to help better disseminate information to the appropriate stakeholders. This includes the sharing of lessons learned.

Reviewer 2:

The reviewer praised the Tiger team concept and program as great. However, the reviewer observed that most of the tasks are reactive (i.e., responding to a call from a coordinator about a crisis). The reviewer stated that if enough resources are available, the reviewer would like to see a more proactive outreach, for example, to key accounts.

Reviewer 3:

The reviewer observed that while the approach to looking at a problem that has been identified and developing a solution is evident, it seems that the Tiger Teams need to be brought into the process earlier. The reviewer stated that a process for more outreach to the Clean Cities coordinators about the Tiger Team program would add value to the project. This would also enable coordinators to assist stakeholders with third party reviews before getting deeper into the project and potentially greater problems.

Reviewer 4:

The reviewer observed that teams have begun to help with fleet analysis and station placement, in addition to reliability issues, and commented that this is good. However, the reviewer also noted that the team is also helping to write requests for proposals (RFPs) for the station bidding processes and cautioned that this may not be the best use of resources of this team, and could possibly result in RFPs that are skewed toward specific technologies. The reviewer suggested it would be beneficial to have a specific process in place once the root cause has been identified to follow up with preventative activities, but added that this process will need to be flexible to accommodate confidential information.

Reviewer 5:

The reviewer asked how are projects selected and with what selection criteria.

Question 2: Project Accomplishments and Progress toward overall project and DOE goals—the degree to which progress/significant accomplishments have been achieved, measured against performance indicators and demonstrated progress toward project and DOE goals.

Reviewer 1:

The reviewer described the project as working, and indicated it was clear that the project had been very successful in finding a solution whenever called upon. The reviewer pointed to case studies from Georgia, Kansas City, and Oyster Bay as good examples of excellent outcomes.

Reviewer 2:

The reviewer observed that while the Tiger teams manage all fuels including hydrogen, they have found that compressed natural gas (CNG) and propane have the most need of the Tiger teams, because many of the vehicles are conversions rather than OEM vehicles. The reviewer remarked that this is a significant finding from this work as it suggests codes and standards around conversions should be strengthened. The reviewer also observed that identification and correction of unsafe installations is a key accomplishment that also helps to ensure continued market adoption by improving safety.

Reviewer 3:

The reviewer stated that the Tiger team supported several incidents, but that there was not much mention of some of the other activities the Tiger team supported.

Question 3: Collaboration and Coordination among Project Team—the degree to which the appropriate team members and partners are involved in the project work and the effectiveness of the collaboration between and among partners.

Reviewer 1:

The reviewer stated that project has been able to maintain the high level of needed technical collaboration, which has been key. The reviewer remarked that the focus on providing technical expertise from industry, local governments, and the communities at large has enhanced the effectiveness of the project.

Reviewer 2:

The reviewer observed that the teams must work with many different customers and consultants and remarked that it is clear through their results that they do this effectively.

Reviewer 3:

The reviewer stated that there is strong collaboration in most of the alternative fuel areas, and suggested a plan forward to address other, new, critical areas.

Question 4: Alternative Fuel Market Expansion and/or Petroleum Reduction Potential—the degree to which the project has the potential to contribute to a sustainable alternative fuel vehicle market and/or reduce petroleum dependence in the transportation sector, including the potential to reduce barriers to large scale alternative fuel vehicle market penetration and make information about alternative fuels and petroleum reduction opportunities widely available to target audiences.

Reviewer 1:

The reviewer stated that the degree to which the project continues to respond successfully to issues facing the alternative fuel community on the front end will go a long way toward getting buy-in that expands the use of AFVs. The reviewer praised the current program as being on track to do just that, and added that while barriers may continue, the Tiger team presents a major solution.

Reviewer 2:

The reviewer stated that as the alternative fuel market expands, there will always be a need to engage and support deployment and praised this project as the right mechanism to do this.

Reviewer 3:

The reviewer remarked that addressing crises quickly makes for happier users, specifically, alternative fuel customers.

Reviewer 4:

The reviewer remarked that ensuring quality work and avoiding incidents that can have a domino effect on the market are critical to alternative fuel vehicle adoption.

Question 5: Relevance: Does this project support the overall DOE objectives of reducing reliance on petroleum based fuels?

Reviewer 1:

The reviewer praised the project's hands-on approach as being able to develop a picture that people can see, enabling better understanding of the cause and the solution, which in turn fosters increased use of non-petroleum based fuels.

Reviewer 2:

The reviewer stated that it is important to support the early market and ensure safety in order to promote adoption.

Question 6: Comments on Use of Resources.

Reviewer 1:

The reviewer stated that safety is extremely critical with new vehicle technologies and praised this team as being extremely important to ensuring good practices.

Reviewer 2:

The reviewer declared that the project must be continued and with increased funding, because it is the only program that provides a process to get needed support to resolve issues that are currently facing stakeholders using alternative fuels. Additionally, the project represents a great tool to help new stakeholders that have issues, and enables them to become users of non-petroleum based fuels.

Reviewer 3:

As previously indicated, this reviewer stated that more resources for proactive outreach (e.g., Kansas City Transit program) would be valuable.

Collegiate Programs: Advanced Vehicle Technology Competitions (AVTC), Graduate Research Assistants (GRCs), and Clean Cities University Workforce Development Program (CCUWDP): Marcy Rood (Argonne National Laboratory) - ti062

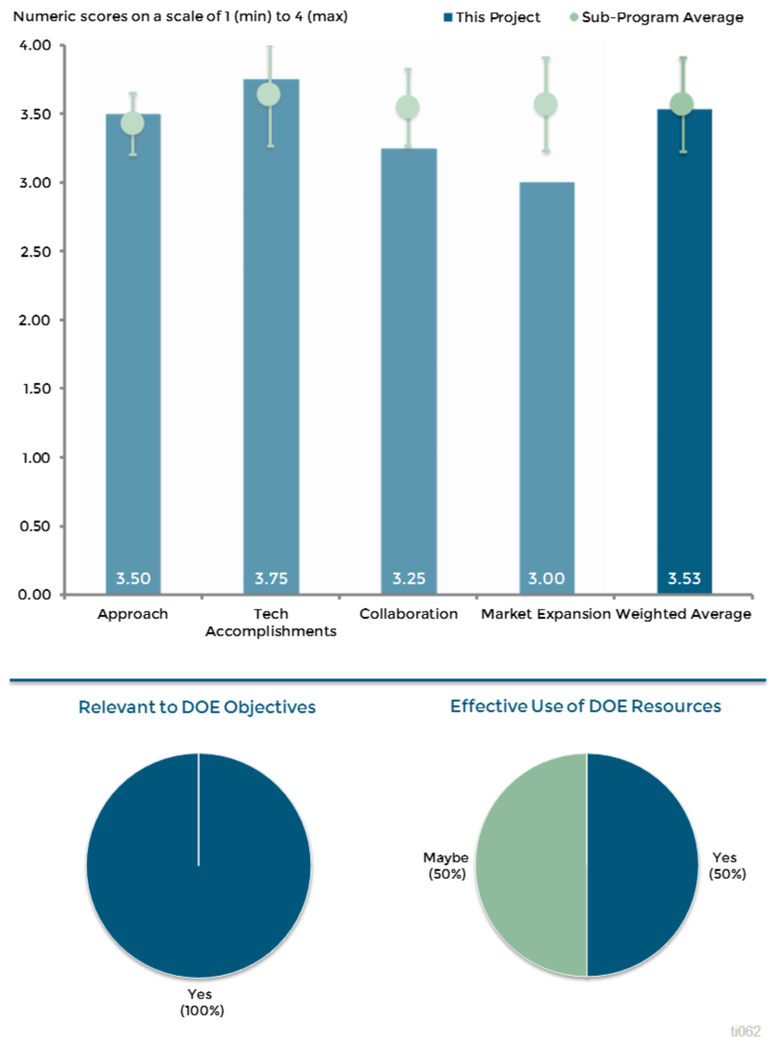


Figure 8-7 Collegiate Programs: Advanced Vehicle Technology Competitions (AVTC), Graduate Research Assistants (GRCs), and Clean Cities University Workforce Development Program (CCUWDP): Marcy Rood (Argonne National Laboratory) - Technology Integration

Presenter

Marcy Rood, Argonne National Laboratory.

Reviewer Sample Size

A total of four reviewers evaluated this project.

Question 1: Project Approach to supporting deployment of petroleum reduction technologies and practices, alternative fuel vehicles, infrastructure and related efforts—the degree to which the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer praised the Collegiate Program project approach as excellent. The reviewer remarked that this program provides support to the Clean Cities coalitions that desperately need the support and to the EcoCAR teams who also very much need the support, while at the same time it invests in the development of future energy professionals. The reviewer described this approach as a win/win.

Reviewer 2:

The reviewer praised the great outcomes in building student skills, improving ability to sit for professional exams, and providing networking opportunities that result in full-time placement. The reviewer observed that these placements are often in petroleum reduction fields. The reviewer suggested that in the technology competition program, there be a look at a two-year timeframe to allow for more teams to get involved, and possibly increasing the number of teams that are able to participate, or increasing funding to support more teams.

Reviewer 3:

The reviewer stated the project is well done for what it is, but questioned the value of it. The reviewer observed that while the project is clearly a big deal for the few people it reaches, this is a very small group. The reviewer remarked that reaching college students is important, but this seems like a very expensive way to do it.

Question 2: Project Accomplishments and Progress toward overall project and DOE goals—the degree to which progress/significant accomplishments have been achieved, measured against performance indicators and demonstrated progress toward project and DOE goals.

Reviewer 1:

The reviewer remarked that it seems that in all categories the outcomes have met or exceeded their goals. The reviewer observed that there is a high graduation and employment rate (in this field) of students in the programs. The reviewer praised the project as playing a major role in the development of future leaders for the alternative fuels and vehicles arena.

Reviewer 2:

The reviewer stated that the program has grown tremendously since a relatively new beginning and that it continues to show growth in the number of coalitions being supported and number of interns being utilized/mentored/trained.

Question 3: Collaboration and Coordination among Project Team—the degree to which the appropriate team members and partners are involved in the project work and the effectiveness of the collaboration between and among partners.

Reviewer 1:

The reviewer praised the collaboration and coordination efforts of this program as being really outstanding. The reviewer exclaimed that there is so much industry support and that does not come easily.

Reviewer 2:

The reviewer observed that collaboration and partnering seems to be at an all-time high with buy-in from OEMs, universities and colleges, technical groups, coalitions, and others. The reviewer observed that students are learning a strong lesson in how working as a team produces a better outcome. The reviewer praised the project as promoting student development, which represents a huge plus for the country and the world.

Question 4: Alternative Fuel Market Expansion and/or Petroleum Reduction Potential—the degree to which the project has the potential to contribute to a sustainable alternative fuel vehicle market and/or reduce petroleum dependence in the transportation sector, including the potential to reduce barriers to large scale alternative fuel vehicle market penetration and make information about alternative fuels and petroleum reduction opportunities widely available to target audiences.

Reviewer 1:

The reviewer praised the project as planting seeds in thousands of young minds that will continue to be concerned about clean energy and petroleum reduction. The reviewer observed that this represents one of the best ways to sustain the objectives and goals of the overall project.

Reviewer 2:

The reviewer stated that this program has significant potential to contribute to a sustainable alternative fuel vehicle market through the following ways: support of the Clean Cities coalitions by providing intern support; support of the EcoCAR program by providing intern support; and investment in future energy industry professionals.

Question 5: Relevance: Does this project support the overall DOE objectives of reducing reliance on petroleum based fuels?

Reviewer 1:

The reviewer observed that students in the project and those touched by it continue to demonstrate that reliance on petroleum-based fuels is no longer necessary. The reviewer remarked that the students' creative projects and educational events have reached thousands of lives, in addition to the thousands it has reached in its direct support to the Clean Cities coalitions.

Reviewer 2:
The reviewer definitively affirmed the value of the project, remarking that it is a huge investment in the country’s energy future by preparing tomorrow's energy professionals.

Reviewer 3:
The reviewer stated there is increased awareness.

Reviewer 4:
The reviewer said the project was valuable but only but marginally.

Question 6: Comments on Use of Resources.

Reviewer 1:
The reviewer praised the funding of this project as representing an excellent use of the DOE budget, in part because it helps to change behavior and how people are thinking. The reviewer stated that the project programs are developing the army of strong proactive individuals needed to ensure our energy independence. The reviewer suggested that additional program funding is needed to bring participates together to exchange ideas and program recommendations, in addition to a focus on lessons learned.

Reviewer 2:
The reviewer agreed that the project appears to be having a significant impact for the budget provided and that project efforts are worthy of continued funding.

Reviewer 3:
The reviewer suggested other options are grants for Ph.D. degrees or natural gas vehicle cylinder training and safety.

Reviewer 4:
The reviewer suggested stepping back and seeing how college students can be reached more efficiently.

Alternative Fuel Tools and Technical Assistance Activities: Marcy Rood (Argonne National Laboratory) - ti063

Presenter

Marcy Rood, Argonne National Laboratory.

Reviewer Sample Size

A total of five reviewers evaluated this project.

Question 1: Project Approach to supporting deployment of petroleum reduction technologies and practices, alternative fuel vehicles, infrastructure and related efforts—the degree to which the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer stated that having a project that has as its focus the analysis side of the clean energy program represents a major support piece in helping stakeholders and fleet managers move to alternative fuels.

The reviewer stated that the technical assistance and tools provide a template for an easy transition to a number of petroleum reduction activities.

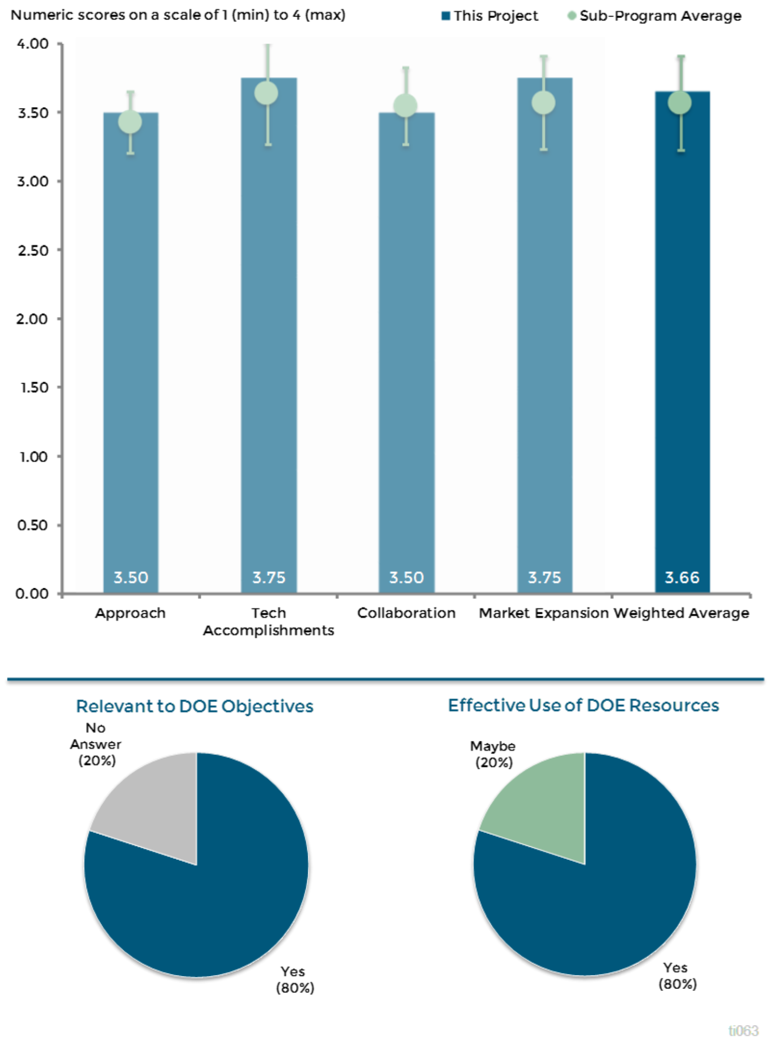


Figure 8-8 Alternative Fuel Tools and Technical Assistance Activities: Marcy Rood (Argonne National Laboratory) - Technology Integration

The reviewer remarked that the Idle Box program approach seems to represent all the components needed to achieve the best outcome and should be duplicated.

Reviewer 2:

The reviewer said that the project approach is very good, but cautioned that as a non-mathematical person, the reviewer found the AFLEET and JOBs tools way too cumbersome for use. The reviewer stated that the goal of each tool is of great value to the user but surmised many others would feel the same apprehension to using the products.

The reviewer stated that the Idle Box materials are very good but are not easy to find on websites. The reviewer stated that the case studies are very good and the outreach efforts are good.

Reviewer 3:

The reviewer praised the AFLEET tool and case studies as great, but that the JOBS tools needs to be made more robust to take into account secondary job impacts.

Question 2: Project Accomplishments and Progress toward overall project and DOE goals—the degree to which progress/significant accomplishments have been achieved, measured against performance indicators and demonstrated progress toward project and DOE goals.

Reviewer 1:

The reviewer remarked that various outcomes noted from white papers, case studies, and webinars all demonstrate project success. The reviewer stated that the data is suggesting a wide use of information and the development of a number of events/activities. The reviewer remarked that the expanded development of the AFDC calculators and quick response (QR) cards have provided some very useful tools for the general public as a whole, and for fleet operators. The reviewer concluded that these tools are very useful for enabling decision makers to better identify what alternative fuel works best for them.

Reviewer 2:

The reviewer remarked that the presentation states that the team is in process of making the AFLEET tool user-friendly. The reviewer praised this as a huge progress point and the reason for rating this section outstanding versus good on the first section. The reviewer recommended a more user-friendly approach for the JOBS Model also be considered.

The reviewer requested seeing more overall outreach and marketing for the project. The reviewer remarked that it is such a consumer program and that it really needs to be pushed out via outlets such as social media, etc. The reviewer also recommended better visibility among program websites.

Reviewer 3:

The reviewer stated that more effort should be put into repackaging the case studies for publication in customer magazines and in presentations to customer conferences.

Question 3: Collaboration and Coordination among Project Team—the degree to which the appropriate team members and partners are involved in the project work and the effectiveness of the collaboration between and among partners.

Reviewer 1:

The reviewer strongly suggested that student representation from the collegiate program be added to the team because their youthful ideas would add enhanced value to the outreach program and help ensure that the projects are being designed to reach this and future generations.

Reviewer 2:

The reviewer praised the outstanding efforts to pull in the right experts/industry partners for support in development and beta testing. The reviewer recommended that beta testing also be conducted by those who have not been involved in the project development so they can bring new insights.

Question 4: Alternative Fuel Market Expansion and/or Petroleum Reduction Potential—the degree to which the project has the potential to contribute to a sustainable alternative fuel vehicle market and/or reduce petroleum dependence in the transportation sector, including the potential to reduce barriers to large scale alternative fuel vehicle market penetration and make information about alternative fuels and petroleum reduction opportunities widely available to target audiences.

Reviewer 1:

The reviewer praised the project for playing a major role in providing tools to help stakeholder resolve issues that had represented barriers to moving into the alternative fuels program. The reviewer remarked that there is a lot of missing/bad information regarding alternative fuels in the public domain but that the project is bringing a great deal of meaningful, accurate, and definable data to the industry.

Reviewer 2:

The reviewer praised the project as having great purpose and stated that the tools and products being developed are highly needed.

Question 5: Relevance: Does this project support the overall DOE objectives of reducing reliance on petroleum based fuels?

Reviewer 1:

The reviewer remarked that clearly the tools not only show the value in why the country should reduce its use of petroleum, but they also demonstrate the economic benefits for the country. The reviewer observed that the expansion of the project's audience helps to lay down a foundation for continuous reduction in petroleum-based fuels.

Reviewer 2:

The reviewer agreed that the project provides tools of great importance that can be utilized by a number of audiences.

Question 6: Comments on Use of Resources.

Reviewer 1:

The reviewer stated that more funding should be put into case studies because these are very valuable sales tools.

Reviewer 2:

The reviewer remarked that the funds seem appropriate for work being conducted and stated that project efforts are worthy of continued funding.

Reviewer 3:

The reviewer remarked that the fact that end products are geared to user needs is a huge plus. However, the reviewer suggested a look be taken to ensure that information provided on the AFLEET program/process is understood by the novice. The reviewer wondered whether a quick study guide or step-by-step approach instructions is needed.

Acronyms and Abbreviations

AFDC	Alternative Fuels Data Center
AFV	Alternative Fuel Vehicle
API	Application programming interface
CNG	Compressed natural gas
DOE	Department of Energy
E85	85 percent ethanol blend with gasoline
EERE	Office of Energy Efficiency and Renewable Energy
EIA	Energy Information Administration
EV	Electric Vehicle
EVSE	Electric vehicle supply equipment
FC	Fuel cell
FE	Fuel economy
FEG	Fuel Economy Guide
FFV	Flex-fuel vehicles
FY	Fiscal year
GHG	Greenhouse Gases
HEV	Hybrid Electric Vehicle
INL	Idaho National Laboratory
MPG_e	Miles per gallon gasoline equivalent
NHTSA	National Highway Traffic Safety Administration
NG	Natural gas
NGV	Natural gas vehicle
NREL	National Renewable Energy Laboratory
OEM	Original Equipment Manufacturer
PEV	Plug-in electric vehicle
PHEV	Plug-in hybrid electric vehicles
PI	Principal Investigator

SUV	Sport utility vehicle
VTO	Vehicle Technologies Office
ZEV	Zero-emission vehicles

9. Vehicle Analysis

The Vehicle Analysis (VAN) subprogram provides testing and analysis relevant to the U.S. Department of Energy (DOE) Vehicle Technologies Office (VTO). The subprogram mission is to plan, execute, and communicate technology, societal, economic, and interdisciplinary analyses for the U.S. Department of Energy (DOE), the Office of Energy Efficiency and Renewable Energy (EERE), VTO, and external stakeholders. Overarching activities within this subprogram serve to develop and deploy vehicle technologies that reduce the use of petroleum while maintaining performance, power, and comfort, and help people access and use efficient, clean vehicles that meet their transportation needs.

Along with work in individual technologies such as combustion engines, batteries, electric drive systems, and fuels, VTO funds research that explores how to connect these components and systems together in the most effective, efficient way possible. Much of this work uses specialized equipment and software that VTO developed in partnership with the national laboratories, including the industry-leading modeling software Autonomie. To inform its activities, VTO also collects and reports its research results, data on individual advanced vehicles, and information on the transportation industry.

Researchers use these approaches to combine multiple technologies within an overarching “vehicle systems perspective”:

- Benchmarking is the process of collecting a standard set of baseline data for a component or entire vehicle. Researchers can use this data to validate models that simulate vehicles or compare it to data from new technologies to see how much they improve on existing ones.
- Vehicle modeling and simulation tools allow researchers to save time and money by building “virtual vehicles” where they can simulate the use of different technologies before building actual components.
- Integration, validation, and testing tools and procedures help researchers combine and test multiple physical components as well as entire vehicles in consistent, cost-effective ways.

Along with improving vehicle technologies, other software packages developed by the national laboratories help researchers better understand consumer behavior, vehicles’ environmental effects, the societal benefits of different technologies, and trends in the transportation system.

Subprogram Feedback

DOE received feedback on the overall technical subprogram areas presented during the 2015 Annual Merit Review (AMR). Each subprogram technical session was introduced with a presentation that provided an overview of subprogram goals and recent progress, followed by a series of detailed topic area project presentations.

The reviewers for a given subprogram area responded to a series of specific questions regarding the breadth, depth, and appropriateness of that DOE VTO subprogram’s activities. The subprogram overview questions are listed below, and it should be noted that no scoring metrics were applied. These questions were used for all VTO subprogram overviews.

Question 1. Was the program area, including overall strategy, adequately covered?

Question 2. Is there an appropriate balance between near- mid- and long-term research and development?

Question 3. Were important issues and challenges identified?

Question 4. Are plans identified for addressing issues and challenges?

Question 5. Was progress clearly benchmarked against the previous year?

Question 6. Are the projects in this technology area addressing the broad problems and barriers that the Vehicle Technologies Office (VTO) is trying to solve?

Question 7. Does the program area appear to be focused, well-managed, and effective in addressing VTO's needs?

Question 8. What are the key strengths and weaknesses of the projects in this program area? Do any of the projects stand out on either end of the spectrum?

Question 9. Do these projects represent novel and/or innovative ways to approach these barriers as appropriate?

Question 10. Has the program area engaged appropriate partners?

Question 11. Is the program area collaborating with them effectively?

Question 12. Are there any gaps in the portfolio for this technology area?

Question 13. Are there topics that are not being adequately addressed?

Question 14. Are there other areas that this program area should consider funding to meet overall programmatic goals?

Question 15. Can you recommend new ways to approach the barriers addressed by this program area?

Question 16. Are there any other suggestions to improve the effectiveness of this program area?

Responses to the subprogram overview questions are summarized in the following pages. Individual reviewer comments for each question are identified under the heading Reviewer 1, Reviewer 2, etc. Note that reviewer comments may be ordered differently; for example, for each specific subprogram overview presentation, the reviewer identified as Reviewer 1 in the first question may not be Reviewer 1 in the second question, etc.

Subprogram Overview Comments: Jacob Ward (U.S. Department of Energy) – van999

Question 1: Was the program area, including overall strategy, adequately covered?

Reviewer 1:
The reviewer said yes, using the pyramid for technical topics along with the goal/objective/strategy overview provided a comprehensive picture.

Reviewer 2:
The reviewer said yes. Mr. Ward gave an appropriately clear presentation on his program area and the general strategy and approach. The reviewer thought the objective might benefit from some revision to align with addressing a concise problem or set of problem and provide actionable findings or results that can result in discrete actions by researchers, policy makers, legislators, regulators, etc.

Reviewer 3:
The reviewer said that the program area was well covered in a clear and concise presentation. The reviewer appreciated that the program manager gave this presentation at the beginning of the VAN session for those reviewers who were unable to attend earlier sessions in the week. This session set the context and tone for all subsequent project presentations successfully.

Reviewer 4:
The reviewer said yes, the goals, objectives, and strategy were adequately covered.

Reviewer 5:
The reviewer sad yes, and detailed that the strategy was described, and that the traditional pyramid clearly laid out the relationships between projects.

Question 2: Is there an appropriate balance between near- mid- and long-term research and development?

Reviewer 1:
The reviewer said yes, there is significant near-term research and development (R&D) with respect to consumer choices (including in the past) as well as long-term prediction models that look out to 2050 and beyond.

Reviewer 2:
The reviewer said yes, and elaborated that this program supports data collection, modeling, and analysis. Data and model development activities needed to provide supporting program analyses were described. The reviewer noted that previous and future fiscal year activities were identified and discussed.

Reviewer 3:
The reviewer said maybe, and noted that there is lots of emphasis on consumer decision modeling. The reviewer suggested that there could be more coordination with the U.S. Environmental Protection Agency (EPA) and the National Highway Traffic Safety Administration (NHTSA), who are modeling actual policy for the mid-term review. The reviewer asked if there is there any possibility of integrating with the rest of DOE, such as with the grid folks from the DOE Office of Electricity Delivery and Energy Reliability (OE).

Reviewer 4:
The reviewer said that, given that many of the models span the horizon in question, the answer would seem to be yes. However, the reviewer thought more discrete segmentation for some of the research is warranted. The types of models, research, or questions that are asked for short-term, mid-term, and long-term are different. Consequently, different resolutions in the output and problem framing are seen or are needed. The reviewer noted that big, overarching models have potential value, as do discrete models that operate within a narrow framework or problem space.

Reviewer 5:
The reviewer said that this is not applicable to this program

Question 3: Were important issues and challenges identified?

Reviewer 1:
The observed an opportunity to explicitly identify challenges more clearly. The reviewer thought that some of this was stated verbally, but not highlighted in the slides.

Reviewer 2:
The reviewer said yes, and explained that key areas of analysis and associated issues and challenges were identified and discussed.

Reviewer 3:
The reviewer said that important issues and challenges were identified for each level of the VTO analysis program, including data quality, model fidelity and validation, and keeping models up-to-date with regard~~s~~ to timely topics.

Reviewer 4:
The reviewer said yes, and described that these include transition and infrastructure and integration of technology improvements.

Reviewer 5:
The reviewer described the identification of important issues and challenges as adequate, and explained that more attention could be given to specific areas in need of focus or that have fallen short. The reviewer suggested that work could improve by grounding in better identification and articulation of problems related to the topic space.

Question 4: Are plans identified for addressing issues and challenges?

Reviewer 1:
The reviewer said yes, and described that data, analysis, and modeling elements key to addressing issues and challenges were identified and plans for addressing those needs were provided.

Reviewer 2:
The reviewer said that for each level of the program, future work was identified to address the challenges above.

Reviewer 3:
The reviewer said that, in general, plans for identifying issues and challenges were excellent. The reviewer detailed that in the analysis program, the survey project, while a small part of a strong research program, is somewhat ad hoc. While future work will make it more consistent and valuable, the emphasis on stated preference is still a challenge.

Reviewer 4:
The reviewer said somewhat, though the reviewer believed that that this could be improved to be more methodical.

Reviewer 5:
The reviewer said that plans were challenging to discern during the presentation.

Question 5: Was progress clearly benchmarked against the previous year?

Reviewer 1:
The reviewer noted that the program manager showed highlights of progress in each of the program areas versus 2014.

Reviewer 2:
The reviewer said yes, and that progress toward meeting key program elements was provided by fiscal year.

Reviewer 3:
The reviewer detailed that Slide 7 clearly showed progress at least in the market, though it was a bit of a leap to attribute this directly to work funded by VTO.

Reviewer 4:
The reviewer noted that for each level in the VTO analysis pyramid, the program manager presented achievements for fiscal year (FY) 2014-2015, but the reviewer was unsure that this was benchmarked against previous years explicitly. However, compared against the program overview from last year, it was obvious that significant achievements have been made.

Reviewer 5:
The reviewer said moderate, and commented that not all projects were reviewed last year. The presentation described illustrative examples.

Question 6: Are the projects in this technology area addressing the broad problems and barriers that the Vehicle Technologies Office (VTO) is trying to solve?

Reviewer 1:
The reviewer said definitely, as there appears to be close coordination and integration with overall DOE and VTO goals.

Reviewer 2:
The reviewer said yes.

Reviewer 3:
The reviewer said yes, and commented that data collection and model development activities directly address the analytical needs of VTO.

Reviewer 4:
The reviewer said that the data, models and analysis supported by this program provide - information critical to understanding how VTO R&D investment can support DOE/VTO goals of reducing petroleum consumption as well as greenhouse gas (GHG) emissions.

Reviewer 5:
The reviewer said topically yes, but as the question and answer (Q&A) and the reviewer suspected, the suite of reviewer comments would show that several of the actual projects or their execution are falling short.

Question 7: Does the program area appear to be focused, well-managed, and effective in addressing VTO's needs?

Reviewer 1:
The reviewer said yes, the focus and management appeared to be robust and effective. The reviewer noted that the program manager did a good job of presenting a confident front for the important work that is funded through him.

Reviewer 2:

The reviewer said yes, and detailed that there appeared ~~s~~ to be excellent collaboration among the project participants. Program goals are well defined and understood by program participants and they provide a cohesive contribution toward the overall objective.

Reviewer 3:

The reviewer said that the program has a clearly articulated goal, objective, and strategy. Each project within the program has a logical place within this plan, with little redundancy.

Reviewer 4:

The reviewer said yes.

Reviewer 5:

In general, the reviewer thought the program is well-managed. The challenge for any DOE program manager is how to balance what should actually be done with the need or expectation to support various projects at national laboratories. This reviewer found it difficult to tell if some of the programs were by choice or out of forced obligation.

Question 8: What are the key strengths and weaknesses of the projects in this program area? Do any of the projects stand out on either end of the spectrum?

Reviewer 1:

The reviewer said that the Data Book and market report are well established products that are widely used and well received, and the reviewer cited the Google impact score. The Greenhouse Gas, Regulated Emissions, and Energy Use in Transportation (GREET) model is also a widely used, highly respected tool for industry.

Reviewer 2:

The reviewer said that while many of these projects address similar issues, each brings a unique perspective to addressing and analyzing the issue in question. All of these efforts stand out as providing a valuable contribution to better understanding issues related to VTO programs, estimating their potential impact in the marketplace, and measuring the associated energy consumption and GHG emission effects of their success.

Reviewer 3:

The reviewer said yes, and noted that VAN0014 stood out as particularly well-constructed and executed. In general, the project researchers seemed to understand how the team fits into the larger model and tool framework pyramid. The reviewer detailed that weaknesses will be included in the descriptions in the individual project reviews. The reviewer commented that, in general, in reflecting on the projects, there seemed to be heavy emphasis on deterministic outcomes that tend to be framed by or constrained with reaching pre-determined outcomes, and little analysis looking at stochastic processes that lead to divergent or undesired outcomes relative to policy objectives.

Reviewer 4:

The reviewer said that while redundancy with regard to market penetration modeling is a good thing (different approaches will yield different results), they do seem to make up the bulk of the program. The reviewer noted that this is especially obvious when examining the summary chart (Slide 21) of the presentation. The reviewer cited a project that stands out as a pillar of the VTO analysis program is GREET, and wondered if perhaps that is why this is the only model covering emissions and environmental modeling.

Reviewer 5:

The reviewer noted that GREET, the Transportation Energy Data Book, and Autonomie stand out as strong. Now that vehicles are in the market, the generic survey work seems less relevant.

Question 9: Do these projects represent novel and/or innovative ways to approach these barriers as appropriate?

Reviewer 1:
The reviewer said yes. In many ways, the data collection and model development projects/activities are innovative and provide insights critical to understanding the potential impact advanced technology vehicles could have in the market. The reviewer said that these projects are key to identifying and understanding consumer acceptance issues and developing tools/models to explore the potential implications associated with those issues. The reviewer commented that gaining this knowledge supports the VTO programs and other stakeholders that support the successful implementation of advanced technologies in vehicles.

Reviewer 2:
The reviewer said yes.

Reviewer 3:
The reviewer said yes, some do. The project led by Manley, in particular, stands out, while the others for the most part do not. The reviewer suggested that it might be worth considering the merits of continuing model development that has spanned more than 10 years in some cases, versus seeking alternative approaches to the scientific inquiry.

Reviewer 4:
The reviewer said there is a moderate amount of innovation being employed. The reviewer got the sense, however, there may be room for innovation, as most of these tools are more conventional data gathering, analysis, and synthesizing the data into graphs and conclusions.

Reviewer 5:
The reviewer said that this question is not applicable to this program.

Question 10: Has the program area engaged appropriate partners?

Reviewer 1:
The reviewer said that there does appear to be wide collaboration within DOE, with various national laboratories, universities, and other Federal agencies.

Reviewer 2:
The reviewer said yes.

Reviewer 3:
The reviewer said yes, both industry and laboratories.

Reviewer 4:
For the most part, this reviewer found that each project within the program area had very good partner engagement. This seemed to the reviewer to be a priority of all VTO analysis programs, such that no principal investigator is working in a vacuum.

Reviewer 5:
The reviewer said yes, some of the partners are appropriate, but there seemed to be a number of missing partners. The reviewer expressed concern that very few universities seemed engaged, which appeared to have led to a group-think mentality and approach as a diversity of approaches and educational backgrounds was lacking.

Question 11: Is the program area collaborating with them effectively?

Reviewer 1:
The reviewer said yes, indications are that collaboration is effective.

Reviewer 2:
The reviewer said yes.

Reviewer 3:
The reviewer noted that the program has strong support from and collaboration among various national laboratories, including Argonne National Laboratory (ANL), Oak Ridge National Laboratory (ORNL) the National Renewable Energy Laboratory (NREL), and Sandia National Laboratories (SNL). In particular, the reviewer noted that van003 and van005 seemed to have made very good use of these collaborations in contribution to their accomplishments this year.

Reviewer 4:
The reviewer said yes.

Reviewer 5:
The reviewer said that effective collaboration varies.

Question 12: Are there any gaps in the portfolio for this technology area?

Reviewer 1:
The reviewer said there appeared to be none.

Reviewer 2:
The reviewer said that the portfolio is comprehensive and covers issues of importance.

Reviewer 3:
The reviewer perceived that the nature of these tools would lend them to plugging into big data and other data streams as well as using tools such as geographic information systems (GIS) to significantly enhance the sophistication and output of the tools.

Reviewer 4:
The reviewer cited the survey of alternative fuel vehicle users. There are additional opportunities to partner with projects that track alternative vehicle owners or buyers. The reviewer saw projects that do this.

Reviewer 5:
The reviewer said yes.

Question 13: Are there topics that are not being adequately addressed?

Reviewer 1:
The reviewer said no.

Reviewer 2:
The reviewer said yes. Additionally, the impact analysis area as presented was lacking. The inability to disaggregate gains toward objectives that would occur, or are occurring independent of DOE activity functionally makes the results useless. The reviewer said that investment by industry, advances driven from outside the United States, advances resulting in investment from other agencies, etc., are occurring. The reviewer said that taking credit for them, and making broad, but illogical, assumptions about technology deployment across multiple platforms simultaneously does not help inform where R&D needs actually exist or where resources can best be applied.

Reviewer 3:
The reviewer was surprised that there is only one model covering the important topic of emissions and environmental modeling, while there are six models covering market penetration.

Reviewer 4:
The reviewer noted surveys of alternative vehicle owners, rather than general consumers. However, the reviewer acknowledged that this is being addressed in one project.

Question 14: Are there other areas that this program area should consider funding to meet overall programmatic goals?

Reviewer 1:
The reviewer could think of none.

Reviewer 2:
The reviewer had no suggestions.

Reviewer 3:
The reviewer said yes. The reviewer identified that alternative (i.e., non-life cycle assessment (LCA)) models to GREET should be an imperative.

Reviewer 4:
The reviewer suggested coordination with NHTSA and EPA on vehicle choice modeling.

Question 15: Can you recommend new ways to approach the barriers addressed by this program area?

Reviewer 1:
The reviewer had no recommendations.

Reviewer 2:
The reviewer said that the current approaches adequately address the barriers.

Reviewer 3:
The reviewer referenced prior comments regarding how employing GIS and plugging into big data sources and analysis tools would be a clear enhancement.

Reviewer 4:
The reviewer said yes, and preferred to have a direct conversation with the program manager.

Reviewer 5:
The reviewer cited transition models. The reviewer suggested working with the policy office or other agencies to look at policies to introduce alternative vehicles.

Question 16: Are there any other suggestions to improve the effectiveness of this program area?

Reviewer 1:
The reviewer said that this is a good program with critical research thrusts.

Reviewer 2:
The reviewer had no additional suggestions.

Reviewer 3:
The reviewer was unsure if linking VTO investment directly to petroleum displacement is accurate. Certainly there is an effect, the reviewer acknowledged, but the free market itself as well as corporations are likely the major drivers here.

Reviewer 4:

The reviewer suggested continuing to solicit a wide variety of stakeholder input. In particular for the system-level integrated analysis, engage with industry to challenge modelers' assumptions and sanity check results.

Reviewer 5:

The reviewer explained that these comments will be expanded on in the individual review, and described reliance on the GREET model as the single model for GHG calculation as problematic. Each of the other areas have multiple models. This is an under-appreciated approach, as it gives a breadth of analysis to provide insight or understanding. The reviewer said that given that all models are wrong, and have limitations as imperfect representations of the real world, it becomes imperative to test and explore using different tools targeted at providing answers to discrete, but limited, problems and questions. The reviewer acknowledged that GREET has value, but it also has its limitations and, worse, is treated as providing an accurate and precise answer which is not the case, especially for several fuel pathways. The reviewer described that there are simply inherent limitations to lifecycle assessment (LCA) as a methodology that cannot be corrected by increasing the complexity of the model, or believing that improved input data is the solution. The reviewer said that the result is potentially, or as some legitimately argue, a history of a misinformed program or belief that some activities and technologies are reducing GHGs (for example corn ethanol, and other biofuel pathways) when credible (peer reviewed) alternative analysis suggests the answer is more neutral or perhaps an increase in GHG. The reviewer explained that this comment is not to argue which answer is right, but to help articulate the need for different types of models and approaches that can provide valid, but alternative insights and complement the findings of GREET.

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.

Presentation Title	Principal Investigator and Organization	Page Number	Approach	Technical Accomplishments	Collaborations	Future Research	Weighted Average
Impact Analysis: VTO Baseline and Scenario (BaSce) Activities	Stephens, Tom (ANL)	9-12	2.58	2.75	3.08	3.00	2.78
Emissions Modeling: GREET Life-Cycle Analysis	Wang, Michael (ANL)	9-17	3.25	3.33	3.00	3.25	3.26
Consumer Vehicle Technology Data	Singer, Mark (NREL)	9-22	2.67	2.92	2.83	2.83	2.83
Unified Modeling, Simulation, and Market Implications: FASTSim and ADOPT	Brooker, Aaron (NREL)	9-27	3.42	3.42	3.08	3.33	3.36
Consumer-Segmented Vehicle Choice Modeling: the MA3T Model	Lin, Zhenhong (ORNL)	9-32	3.08	3.17	3.42	3.33	3.20
Parametric Vehicle Choice Modeling: ParaChoice	Manley, Dawn (SNL)	9-36	3.25	3.42	3.25	3.25	3.33
PEV Consumer Behavior in Practice (PCBIP)	Nicholas, Mike (UCD)	9-41	3.33	3.08	2.83	2.83	3.08
Overall Average			3.08	3.16	3.07	3.12	3.12

Impact Analysis: VTO Baseline and Scenario (BaSce) Activities: Tom Stephens (Argonne National Laboratory) - van001

Presenter

Tom Stephens, Argonne National Laboratory.

Reviewer Sample Size

A total of six reviewers evaluated this project.

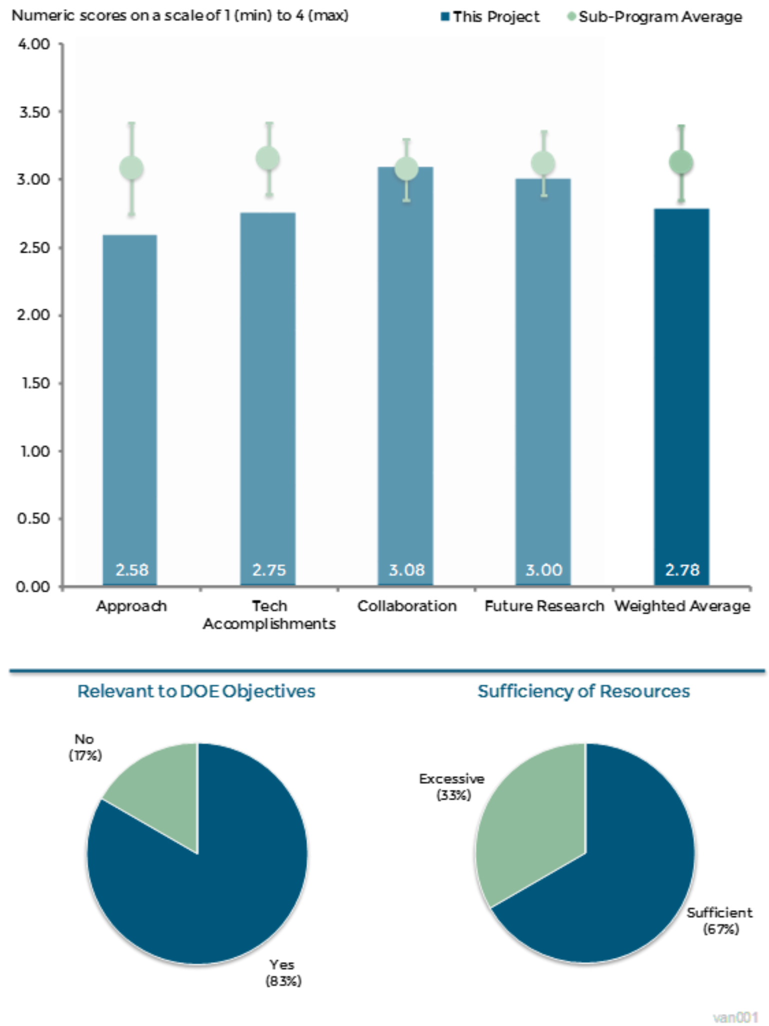


Figure 9-1 Impact Analysis: VTO Baseline and Scenario (BaSce) Activities: Tom Stephens (Argonne National Laboratory) – Vehicle Analysis

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer noted that the project is fully relevant, and it is valuable to estimate effects of program goals, fleet level analysis. Benefits analysis of completely successful fully commercialized VTO. The reviewer asked if the project team uses the Vision model and then GREET. The reviewer added that the no program case and interaction with corporate average fuel economy (CAFE) standards are not clear. It looked like the counter-factual case is not integrated assuming model years (MY) 2017-2025 CAFE standards.

Reviewer 2:

The reviewer reported that the analytical approach provides an effective process for measuring potential energy and emissions impacts of fully successful R&D programs. Market adoption of technologies presented was very aggressive and may overstate the potential impact given financial investment needed to support production. The reviewer added that as stated by the presenter, the process could be improved through additional sensitivity analyses addressing uncertainties in consumer behavior and/or acceptance, fuel prices, and fueling infrastructure development.

Reviewer 3:

The reviewer commented that this project seeks to quantify petroleum, GHG emissions, and level cost of driving reductions that can directly be attributed to VTO program. By nature, this project must be well integrated with all other VTO analysis activities, according to the VTO portfolio pyramid. The reviewer added that one comment from previous reviews that still seemed to be an open issue is how the supply-side is modeled: for example, how to disaggregate improvements from VTO R&D versus regulation and consumer market demands. One suggestion is to refocus the model to address actual gaps (what industry is struggling with versus what they already have in hand) as a way to better overcome barriers.

Reviewer 4:

The reviewer noted that the project provides a method of analyzing the impact of VTO targets by synthesizing VTO analysis models. The analysis provides estimates of how VTO programs affect petroleum use and GHG emissions. However, without validation of the combined model, it is difficult to have any confidence in the results. Also, the reviewer said that the counterfactual, no program case is based on consultations with the VTO, which is welcome, but it is not clear that the assumptions for this case characterize the technological progress and purchasing and driving behavior that would result from additional factors external to the VTO program. The reviewer added that the project would benefit from considering the influence of regulations, incentives, demographic changes, and other factors that would affect petroleum and GHG reductions in the no program case, and making all assumptions and results from this case transparent.

Reviewer 5:

The reviewer said that how the research disaggregates the improvements from VTO research from improvements from industry and other research was unclear. The research does not seem to factor or consider technology path dependence. The reviewer added that there is no justification for aggregating all of the improvements as that is an unrealistic view of technology deployment. This would lead to investment in R&D that will have negligible if any end-use benefit.

The reviewer strongly emphasized that the lack of rational fiscal constraints in the model and analysis makes it hard to extract value. The comments from the prior peer review were spot on, but do not seem to be functionally addressed. The reviewer also said that when rational constraints are imposed it reveals the need to target investment and R&D. Unfortunately, the research fails to inform what areas should be prioritized and what should be diminished.

Reviewer 6:

The reviewer stated that although the approach seems reasonable in principle, in practice the reviewer was not sure how defensible any analysis is that estimates the impact of VTO investments versus no investments as there are so many other market driven, original equipment manufacturer (OEM)-driven, and other factors.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer reported that the project has made good progress, but is behind on a couple of milestones.

Reviewer 2:

The reviewer stated that the analytical tools and models used are appropriate for this analysis.

Reviewer 3:

The reviewer said use vehicle choice models previously mentioned, and that this is an excellent use of these models.

Reviewer 4:

The reviewer noted that the fleet-level analysis is behind schedule but the explanation was that the scope of this task grew significantly in the interim. The results that have been shown meet the goals of showing petroleum, GHG emissions, and cost savings in the case of VTO program success versus a baseline of no further investment. The reviewer added that savings are broken down by technology area, which is useful. It is unclear what assumptions go into that baseline case and the reviewer would like to see some uncertainty analysis performed.

Reviewer 5:
The reviewer pointed out that the project team showed various graphs and results, but the reviewer did not feel the methodology was articulated well enough to build confidence in the results, for example, why any of these results should be believed. There also appeared to be a lack of validation of results, or at least no words paid to validation, which is an answer to the question of was the right thing built, as opposed to verification of was it built right.

Reviewer 6:
The reviewer said that the optimistic market penetrations are not given in context. This is not useful for informing tech development, as the results seem to be presented as likely or expected outcomes, which is very misleading

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer said that the project team has excellent collaboration.

Reviewer 2:
The reviewer remarked that there is commendable collaboration and coordination across and between analytical teams.

Reviewer 3:
The reviewer commented that the project has a strong set of diverse collaborators from the national laboratories, industry, and research organizations. It could benefit from collaboration with OEMs.

Reviewer 4:
The reviewer stated that the project team's collaboration appears to be improved from the last review, and noted collaboration with Volpe should be beneficial to improving results and confidence. A number of collaborations were mentioned, or at least their emblems were shown, but the project team did not provide any depth to the collaboration, so it was hard to assess how well this was actually going other than the comment about the U.S. Department of Transportation (DOT)-Volpe.

Reviewer 5:
The reviewer said that on the modeling side, the project has strong collaborations with several national laboratories through use of other VTO Analysis models. The reviewer suggested expanding industry stakeholder input with regard to supply-side constraints in the model.

Reviewer 6:
The reviewer noted that the project team's collaboration is largely limited to national laboratories which significantly limits the perspective. It was noted that component level attributes seek industry experts, but does not explain how, or address potential biases in this stage of information collection.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer commented that future work to compare results of different vehicle choice models as well as to conduct sensitivity analysis is sensible. The reviewer recommended to also prioritize improving supply-side constraints.

Reviewer 2:
The reviewer stated that the areas of future work, sensitivity analysis, etc., were defined and discussed.

Reviewer 3:
The reviewer reported that future research addresses vehicle choice model assumptions, sensitivity to other variables, and the scope of benefits analyzed. The project would benefit from performing several validation tests of the full model, particularly by comparing predictions of a program success case from past years with historical data of market penetration of various vehicle types.

Reviewer 4:
The reviewer stated that sensitivities against parameters are needed, but was not sure how much relevant ownership costs will substantively change results considering other uncertainties. The reviewer added that there definitely needs to be a fuel price sensitivity case, and that a comparison between vehicle choice models would be useful.

Reviewer 5:
The reviewer said that the proposed future research seems adequate, but not outstanding. The project team seemed to lack a vision of incorporating innovation into the future plans.

Reviewer 6:
The reviewer observed that at a macro level, the proposed future work seems to touch on relevant areas, but it is not fully clear how it will be executed or how it will address the barriers.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer observed that the work is assessing the impact of the VTO program on petroleum and GHG reductions and related impacts (e.g., externalities and social costs), and is an important contribution to achieving the program’s goals.

Reviewer 2:
The reviewer pointed out that evaluation of the impact of VTO programs is a critical requirement in estimating their impact on petroleum displacement.

Reviewer 3:
The reviewer reported that analytical activities and models used to examine potential impacts are appropriate for intended evaluation.

Reviewer 4:
The reviewer commented that a well-developed, robust model to estimate VTO's potential petroleum use and GHG emissions reductions, is a key tool to ensure all VTO projects support the DOE objective of petroleum displacement.

Reviewer 5:
The reviewer stated that the goal of assessing the value of the VTO program whose goal is also petroleum displacement, should, in theory, reduce petroleum use.

Reviewer 6:
The reviewer described the relevance as unclear. Failing to disaggregate the accomplishments that industry and others are bringing to market in response to regulatory (e.g., CAFE, etc.) and consumer demand from VTO contributions does not allow for informing targeting R&D by VTO to address gaps that exist in the broader universe of R&D.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer stated that the budget seems to be a reasonable allocation given the current and proposed scope of work.

Reviewer 2:

The reviewer commented that the financial resources are not the limitation on the project.

Reviewer 3:

The reviewer observed that the funding level for this project is large compared to other VTO analysis projects of similar scope. The project's simulations are largely based on existing models. The reviewer added that the current and proposed future work is worthwhile, but the contributions do not merit the full magnitude of the funds provided.

Reviewer 4:

The reviewer said that based on the presentation, the funding level seems high compared to the results. It was difficult to discern if the issue was simply that the benefits were not well articulated, or if the benefits, themselves, did not really exist, particularly as compared to the level of funding.

Emissions Modeling: GREET Life-Cycle Analysis: Michael Wang (Argonne National Laboratory) - van002

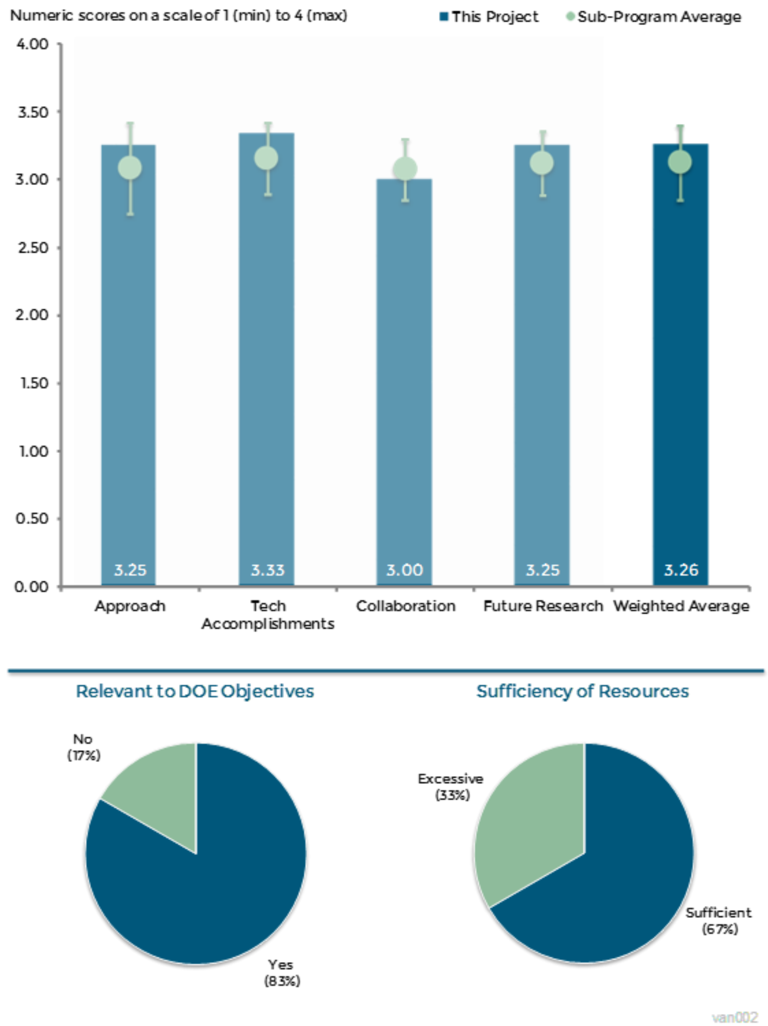


Figure 9-2 Emissions Modeling: GREET Life-Cycle Analysis: Michael Wang (Argonne National Laboratory) – Vehicle Analysis

Presenter

Michael Wang, Argonne National Laboratory.

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer noted that GREET provides a valuable service as an open-source database and transparent LCA methodology. It is particularly helpful that stochastic modeling is built into GREET and that sensitivity analysis can be readily performed.

Reviewer 2:

The reviewer said that the project work is a standard tool for static estimation of GHG emissions, which now includes a stochastic option and is used by major regulatory agencies using open and transparent data.

Reviewer 3:

The reviewer noted that the approach seems the most reasonable to building the model.

Reviewer 4:

The reviewer stated that the project had a very detailed approach to examining trade-offs of GHG emissions.

Reviewer 5:

The reviewer observed that over the past 20 years, the GREET model has established itself as the standard platform for agencies, research institutes, and industry, and it continues to expand pathways and make modeling improvements each year, all in accordance with International Organization for Standardization (ISO) standards.

Reviewer 6:

The reviewer said that the work only marginally addresses environmental sustainability. System boundary factors and considerations limit the ability of the model to accurately answer some fundamental questions on sustainability. The reviewer explained that the limitations are more acute for some fuel pathways such as biofuels and, more broadly, renewables, or powertrains that use renewables. System feedbacks, and dynamic changes over time are not captured.

The reviewer also stated that the emphasis on data and adding more complexity is a distraction from addressing fundamental structural issues that limit the accuracy or validity of the information generated by the model. The model uses a static measurement, even with considering variability, but does not seem to address how the assigned values change over time as with use, resources, etc. The reviewer expressed that the question of what the marginal or induced emissions are is inadequately addressed, or is poorly explained. Noting that oil sands or heavy crude is expected to increase 14%, does not explain how this is factored into the LCA overall product lifetime. The reviewer added that if the objective is to develop indicators and methods for evaluating environmental sustainability, the limitations of LCA preclude the model from being useful in the way it is presented or intended to be used to a large degree. Providing answers, independent of their accuracy, on discrete technology pathways does not answer the more holistic question because it does not answer the impacts or effects on other components or the system outside of the boundary considered in the LCA calculation.

The reviewer also said that improving data helps but only in applications or specific pathways where the model itself is appropriately robust. The reviewer explained that adding good data into a flawed or misapplied model does not necessarily give a more useful answer than bad data into the same model. If GREET were better framed or limited in its scope in how it is utilized, this ranking would go up substantially. The reviewer explained that the poor ranking reflects the potential or likelihood of GREET as currently used providing misleading information in some areas. This overwhelms the value it offers in some areas of providing valuable information. To frame in an alternative way, the research provides a bi-modal value, but this ranking reflects the greater concern or consequences where it falls short.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer pointed out that the project demonstrated good progress in adding new sustainability metrics such as water consumption and detailed examination of methane leakage in the natural gas (NG) supply chain to develop indicators and methodology for evaluating environmental sustainability. The inclusion of new vehicles and fuels, and continued upgrades of the user interface and database, are very helpful to expand the usefulness of the tool. The reviewer added that the causes of the significant differences between the bottom-up and top-down analysis of NG leakage were not addressed, nor was any guidance provided on the circumstances in which one method may be more accurate or appropriate for use in an analysis.

Reviewer 2:

The reviewer reported that the additions to GREET in the last year are topical and aligned with DOE goals. Examining the methane leakage uncertainty in NG pathway GHG effects is critical to understanding how this fuel should be used. The reviewer added that inclusion of the water consumption sustainability metric is also a great addition to the tool.

Reviewer 3:

The reviewer commented that the model is addressing some very important issues, such as NG leakage percentages. One suggestion would be to not only look at the leakage percentages, but also to start quantifying the total leak volumes, ideally geographically, so that overall impact to climate change could be quantified. The reviewer remarked that in other words, a high percentage leak of a small total amount of NG is likely not nearly as harmful to climate change as a medium percentage leak of a large total amount of NG. The reviewer applauded the inclusion of water use and other sustainability metrics that are clearly growing in importance.

Reviewer 4:

The reviewer noted that the inclusion of methane leakage is a valuable improvement.

Reviewer 5:

The reviewer observed that the accomplishments included petroleum refinery GHG estimates. The reviewer said that added water consumption is a timely improvement. NG leakage is also very timely, as is light-weighting.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer noted that the GREET team seems to have strong interactions with agencies, labs, academia, and industry. There does not seem to be much interaction with OEMs.

Reviewer 2:

The reviewer commented that there are a number of organizations that could be included as collaborators to enhance GREET's methodology and data collection. The reviewer was surprised that EDF Environmental Energy was not consulted during the development of the NG leakage studies. The project could also benefit from increased collaboration with OEMs and other industry groups with expertise in materials and fuel systems.

Reviewer 3:

The reviewer said that the project team uses a variety of tools from other labs and industry, including NREL and ORNL, Jacobs, etc.

Reviewer 4:

The reviewer expressed disappointment that there was not a connection stated to anywhere within DOT. Although DOT is primarily concerned with transportation safety, there are many other programs and divisions that research GHG, energy efficiency, and related topics. The reviewer suggested the creation and strengthening of collaboration with DOT, for it was seen to be mentioned in the future work slide. Otherwise, the team does have a comprehensive collection of collaborating or coordination with organizations.

Reviewer 5:

The reviewer stated that the collaborations of the project team help with some data, but do not provide a breadth of perspective on fundamentals. Emphasis seems to be on self-reinforcement

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer said that the direction of the research and upgrades to the platform are really excellent. Overall, this is a very high-impact and important tool for the private sector, academia, and government.

Reviewer 2:

The reviewer expressed that the future work seems reasonable with the GREET model's current status and present topics in the area of expanding the model. In particular, expanding inclusion of light-weighting materials and improving plug-in electric vehicle (PEV) technologies should be emphasized in the year to come.

Reviewer 3:

The reviewer reported that the future proposed work will include additional material and fuel options and indicators, for example, light-weighting materials, heavy crudes, and water consumption, which will help expand the usefulness of the tool for different analyses. It is also helpful that future work will engage with OEMs.

Reviewer 4:
The reviewer noted that the project team added Bakken crudes and additional refining. Refined light-weighting and electric vehicle (EV) characterization are both useful.

Reviewer 5:
The reviewer commented that the future work seems acceptable, but was not well explained on how it relates to the barriers.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer remarked that this is an excellent analytical tool for evaluating energy and emission trade-offs between vehicle technology and fuel platforms.

Reviewer 2:
The reviewer said that the GREET model supports decision making when evaluating vehicle and fuel systems by providing a consistent, well-developed platform.

Reviewer 3:
The reviewer stated that the availability of consistent and transparent data and methodologies to assess life-cycle petroleum use and GHG emissions is critical to inform RD3 sustainable solutions for lower-petroleum, lower-GHG technologies.

Reviewer 4:
The reviewer pointed out that LCA on energy and GHG consumption informs policy-makers on what the best options are for petroleum displacement.

Reviewer 5:
The reviewer observed that this is a robust model used to deeply understand the whole life cycle of various vehicle and fuel pairs that will help shape not only policy, but product choices at OEMs as well.

Reviewer 6:
The reviewer commented that again, this was a challenging response. GREET has the potential to support the overall objective of petroleum displacement, although the work speaks more to sustainability and GHG reductions. The reviewer added that if the objective is just petroleum displacement, then the model is not needed. If the objective is broader, then the uncertainty exists. The reviewer commented that as earlier, there is the potential for some good insights, but as the model is used, it also provides inaccurate or misleading insights which counteract and can undermine accomplishing the objectives.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer stated that this is the most valuable set of research projects in the portfolio.

Reviewer 2:
The reviewer said this is a very valuable tool with a significant stakeholder and user base, and continued support is recommended.

Reviewer 3:
The reviewer reported that the budget seems to be a reasonable allocation given the current and proposed scope of work.

Reviewer 4:

The reviewer noted that the funding for this project is quite high, although the scope of the project is notably larger than other VTO Analysis projects, and that it is certainly true that significant resources are required to constantly upgrade a modeling tool of this scale, collect and verify data, and develop strong connections with non-governmental organizations (NGOs) and OEMs to review the data and methodology to ensure it is of the highest quality available. However, the reviewer expressed a concern that by concentrating so much funding on one single tool, the VTO will not be well informed of the energy implications of various vehicle and fuel options because it is relying on one single tool with a particular set of assumptions and methodological choices that cannot be fully validated. It would be more instructive to encourage development of an alternative analysis tool to help calibrate GREET's predictions, even if it is an adaptation of the GREET model based on the open-source code but with modified methodological choices.

Reviewer 5:

The reviewer stated that resources could be better spent elsewhere, and using resources to add complexity does not necessarily make the model better.

Consumer Vehicle Technology Data: Mark Singer (National Renewable Energy Laboratory) - van003

Presenter

Mark Singer, National Renewable Energy Laboratory.

Reviewer Sample Size

A total of six reviewers evaluated this project.

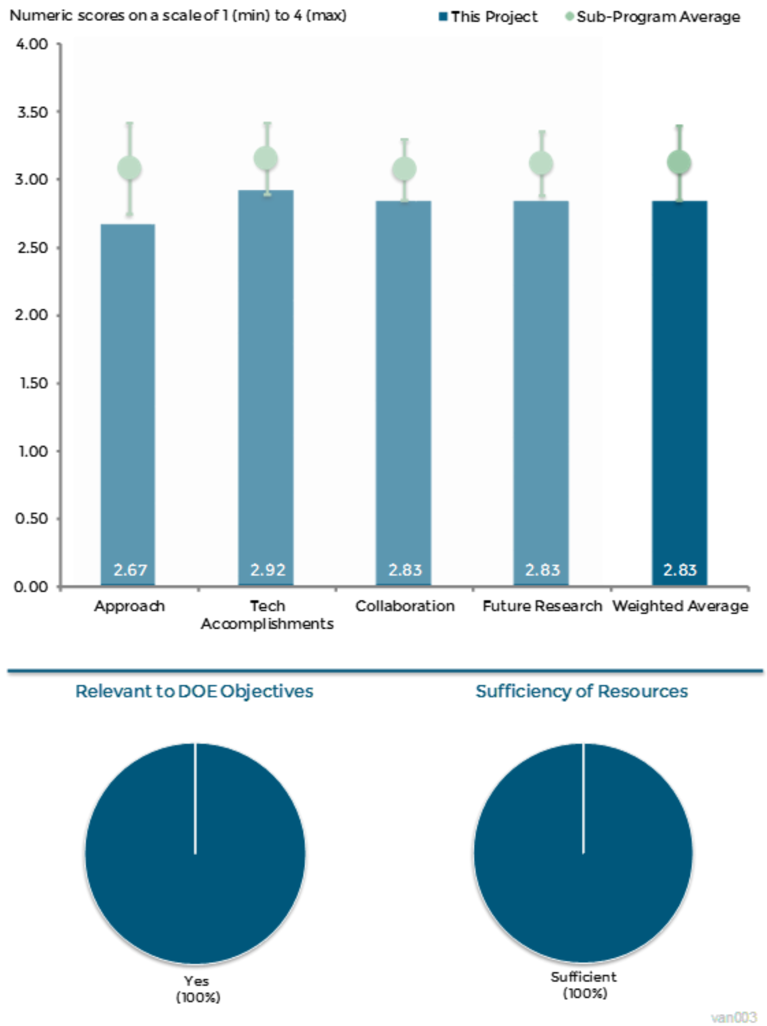


Figure 9-3 Consumer Vehicle Technology Data: Mark Singer (National Renewable Energy Laboratory) – Vehicle Analysis

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer noted that the approach does seem robust, but had the impression that there has not been much innovation in data gathering or analysis for some time. Perhaps this is the nature of the work, but it seemed there is an opportunity here, although it was not immediately clear how these results are or will be used. The reviewer added that the data is certainly interesting, but would suggest a stronger answer to the question of so what, one that really articulates why all of this data gathering matters. This is especially important to address with respect to the other marketing surveys and OEM marketing departments that are doing much of the similar types of analyses.

Reviewer 2:

The reviewer stated that it was challenging to evaluate; the 22 questions were not provided to reviewers. The design of the study, including the questions, is fundamental. The reviewer added that the high level overview that was given suggests the structure of the survey is not well constructed, and questioned if there was any longitudinal work performed. The reviewer also said that if this has been ongoing for 10 years, the researchers should have been able to not only track trends, but also compare survey results to actual consumer behavior. The presenter seems to have inherited a disjointed or poor project; however, at that point, the work should have gone back to the beginning to do some data quality analysis before actually conducting further analysis and presenting results that were preliminary or otherwise. The reviewer said there needs to be a reconciliation of the revealed versus stated preference data. Standardizing the questions and trying to establish some type or longitudinal analysis is a good start.

Reviewer 3:

The reviewer commended the principal investigator (PI) and the project team on their work putting the structure in place to transition the project from a disparate series of studies into a single study that can be tracked longitudinally. In such an early market, this is incredibly relevant work toward both barriers. Thus far, the results were a little concerning regarding whether the 1,000 adults constitute a representative sample of the U.S. market, for example, 5% compressed natural gas (CNG) vehicle drivers, and how closely the survey results translate to actual consumer behavior as stated preference versus revealed preference.

Reviewer 4:

The reviewer said that this project has a significant weakness in relying solely on stated preferences and self-reported information from surveyed individuals. Efforts to address this weakness were not described. It was not clear that the current methods can provide useful information because the stated preferences cannot be verified to be a sign of actual choice behavior. The reviewer added that future work should focus on testing the accuracy of the collected stated preference data, for example by comparing survey responses of the type and segments of vehicles owned with the actual vehicle models owned, and comparing responses on the type of vehicle the individual expects to purchase next and its most important attributes with the actual choice.

Reviewer 5:

The reviewer observed sound analysis of the older, unpublished data. No statistical uncertainty measures were reported, but should exist. The reviewer added that the question of "time from last purchase or until next purchase," conflates a stated and revealed preference. The reviewer added that this raises the broader question of how much value we should place on stated preference when more and more alternative vehicles are entering the market.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer reported that it is a good idea to summarize previous data, and again, the value of stated preference is declining as more vehicles enter the market. Furthermore, the reviewer said that the percentage of ownership of alternative-fuel vehicles is unusual relative to the known numbers of 5% CNG vehicles, which raises questions about the validity of the sample.

Reviewer 2:

The reviewer pointed out that collecting information on current vehicle ownership could help improve understanding of consumer behavior by identifying revealed versus stated preference responses.

Reviewer 3:

The reviewer commented that the project has made progress by standardizing the questions across years to collect longitudinal data; however, significant issues with the methods remain, particularly the fact that the analysis results rely solely on stated preference data that is not compared with any objective measures.

Reviewer 4:

The reviewer commented that the results and insights fall short of a range of other available studies, analysis, and data. For example, King Abdullah Petroleum Studies and Research Center (KAPSARC) has completed a far more detailed analysis of consumer purchasing trends and motivations. The reviewer asked whether survey results, such as cumulative payback, seem to align with consumer purchasing habits. Noting that 5% of households have a CNG vehicle, and 1% EV ownership, the reviewer rhetorically asked whether this indicates survey bias. The answer would seem to be yes. One would likely guess there was either a heavy California bias and/or fleet bias, neither of which accurately reflects broader national trends. The reviewer also asked why the data set was not compared to the national fleet mix and questioned where the statistical analysis is for the data sets. At this point, the usefulness or confidence in the analysis and output is limited and potentially misleading. The reviewer added that there is very little to show for 10 years of work. The previously noted lack of consistency in questions is just one example that limits the usefulness, for the stated versus revealed preferences is another example.

Reviewer 5:

The reviewer said that the right hand graph on Slide 9 could be reformatted to be much easier to read. For example, it is very difficult to tease out how these responses have changed from year to year. The reviewer also stated that the data is there, but drawing conclusions is challenging without very careful study. While the accomplishments are very useful and well represented, the reviewer suggested there are more impactful ways of presenting the graphs and data.

Reviewer 6:

The reviewer indicated that it was not clearly stated in the presentation how this project is related to overall DOE goals, but when asked, the PI stated that understanding the customer adoption barriers to new technologies helps the design and deployment of such technologies. The reviewer said that to this end, the results presented included consumers' preferences for battery range, incremental costs of PEVs, and some infrastructure coverage. The reviewer recommended the expansion of infrastructure awareness questions, especially as public and workplace charging is rapidly developing in certain regions.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer remarked that several national laboratories are included as partners and a well-established polling company is being used to conduct the survey. The project would benefit from collaboration with OEMs.

Reviewer 2:

The reviewer commented that the workgroups initiated by this program demonstrate a dedication to strong collaboration between experts including ORNL, NREL, ANL, SNL, University of California-Davis, Navigant, and California Air Resources Board (CARB). It is particularly important to get these survey questions correct at the beginning for any type of long-term trends analysis of the results.

Reviewer 3:

The reviewer stated that using commercial surveying leverages collaboration with other organizations well.

Reviewer 4:

The reviewer reported the coordination does appear to be adequate, but wondered if there should be more OEM or private- sector coordination if possible. The questions of who is the ultimate customer and how this will influence petroleum displacement are important to address.

Reviewer 5:

The reviewer stated that coordination exists, but that does not speak to the quality of those coordinating organizations. While the list includes a lot of interested or vested parties, it does not reflect many of the leading institutions or organizations who conduct survey work and analysis: University of Michigan is recognized as far superior in their consumer and societal survey work to the University of California-Davis, but it is unclear what they contributed. The reviewer added that the California bias in collaborators may also help explain what appears to be some survey data bias. The information did not clearly articulate how the collaboration was conducted nor what each party was responsible for.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer observed deep-dive investigations, but would have liked to see several deep-dive investigation proposals based on the recent survey results (e.g., whether people do not understand the difference between a Prius hybrid electric vehicle (HEV) and plug-in hybrid electric vehicle (PHEV)). Regarding expanded collaboration, the reviewer was not clear about what form this collaboration would take, and said consumer travel behavior and preferences toward vehicle technologies vary significantly by region, so it would be interesting to explore the regional differences in FY 2016.

Reviewer 2:

The reviewer said that the future work includes comparing survey results to other data such as Polk, which will help to verify the findings, but methods of comparing self-reported responses to objective measures or otherwise addressing the significant drawbacks of relying on stated preferences were not addressed in future work.

Reviewer 3:

The reviewer stated that the project seemed to lack an ambitious vision and innovation looking into the future, evidencing more of a turn-the-crank mentality.

Reviewer 4:

The reviewer was unsure if biofuels or CNG are that important, and asked if the fuel cell and hydrogen work is forward-looking.

Reviewer 5:

The reviewer said there was insufficient information provided to effectively evaluate this.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer indicated that understanding consumer attitudes underlies all of the consumer preference modeling.

Reviewer 2:

The reviewer stated that identifying consumer perception barriers to PEV deployment is important to inform efforts to reduce petroleum usage.

Reviewer 3:

The reviewer stated that in theory, yes, the work meets DOE objectives, but in practice, it is inconclusive at this point.

Reviewer 4:

The reviewer said that the work possibly meets DOE objectives, but the link is a little weak. How this interacts with surveys already going on by private marketing companies and OEMs is not clear, because the latter have a much more direct relationship to future product planning for higher efficiency and/or alternative fuel vehicles.

Reviewer 5:

The reviewer commented that the presentation stated: “Provides robust assumptions for consumer choice research and supports the alignment of program budget priorities with marketplace opportunities.” It was unclear why the PI would categorize the results of this work as robust yet, but the reviewer thought the project is on the right track in terms of trend analysis and collaborative input to provide input on consumer choice that is the foundation upon which the modeling efforts are built.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer commented that funding and output seem aligned.

Reviewer 2:

The reviewer stated that budget seems to be a reasonable allocation given the current and proposed scope of work.

Reviewer 3:

The reviewer said that the resources are sufficient, but the emphasis on survey data of all consumers may be misplaced.

Reviewer 4:

The reviewer said that the resources are sufficient to achieve the stated milestones, but the fact that the project relies solely on stated preferences calls into question the value of this research. The project may merit additional funds if a sound plan can be put into place to address this weakness and bring in the needed expertise to design and validate a more effective survey.

Unified Modeling, Simulation, and Market Implications: FASTSim and ADOPT: Aaron Brooker (National Renewable Energy Laboratory) - van004

Presenter

Aaron Brooker, National Renewable Energy Laboratory.

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

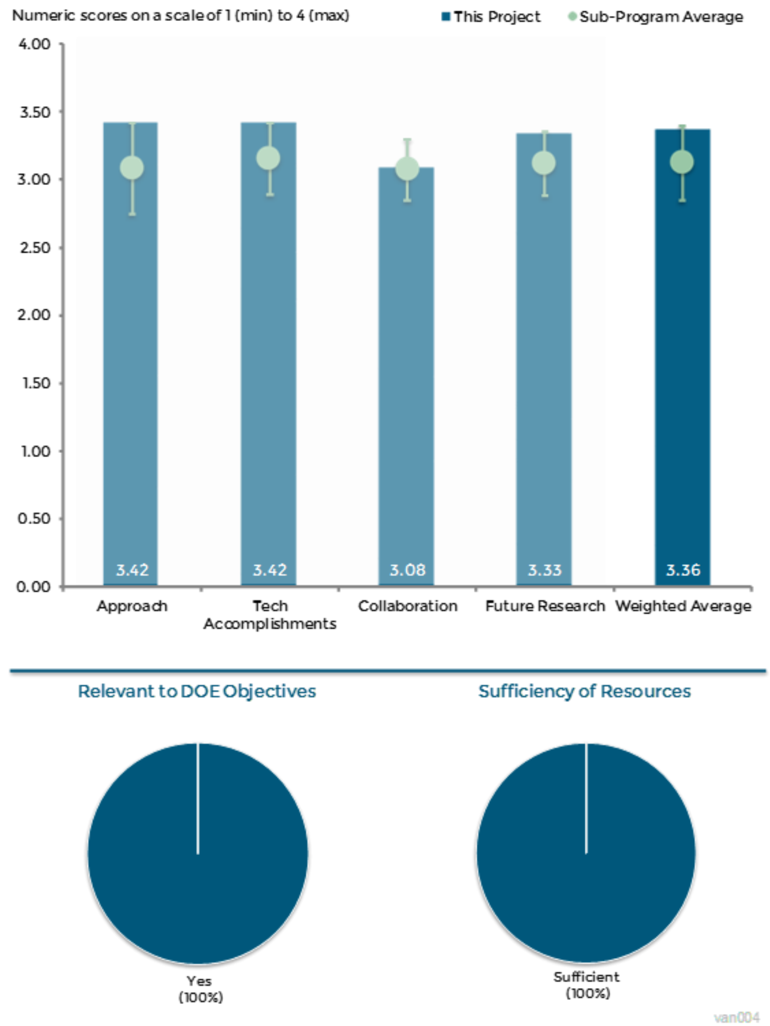


Figure 9-4 Unified Modeling, Simulation, and Market Implications: FASTSim and ADOPT: Aaron Brooker (National Renewable Energy Laboratory) – Vehicle Analysis

Reviewer 1:

The reviewer commented that the approach is very comprehensive to modeling consumer behavior.

Reviewer 2:

The reviewer explained that this is a very valuable program, but there is very little on infrastructure limitations, which play a crucial role in technology adoption. The program needs to look at shifts in the fleet composition as much as technology improvements. The reviewer added that validation with percent of HEV sales, etc., is useful but is not a perfect analogue to other technologies.

Reviewer 3:

The reviewer stated that the approach to the vehicle choice model seem reasonable. Understanding economics and econometrics to incorporate various elasticities of demand for different vehicle attributes is key.

Reviewer 4:

The reviewer explained the stated approach includes all relevant VTO technologies, captures key consumer choice aspects, validates relevant dimensions, understands the results, and expands tool use. The reviewer then pointed out that stated barriers are many, and they impact DOE vehicle technology targets on DOE end goals. The reviewer’s main takeaway from the accomplishments this year was an improvement of the model in every step of the above-stated approach. The reviewer expressed a need to better understand what metric this improvement is measured against. When possible, results were validated against historical results or back-casting, but in some cases, this is not possible. The reviewer also said that a number of HEVs was used as a proxy for fuel cell electric vehicle (FCEV) offerings, for example, but it is not clear why this assumption can be made or how sensitive the results would be to such a key consumer choice aspect.

Reviewer 5:

The reviewer commented that the model is generally well designed with many important consumer choice aspects, for example, heterogeneity of preferences across consumer population and nonlinearity of preferences. Validation of the consumer choice model and the complete connected model is taken seriously. The reviewer added that the work to create an intuitive and easy-to-use interface that helps users visualize the results is also an important aspect of this project. Even with these accomplishments, additional improvements could be made, particularly regarding validation and comparison of the model with alternative approaches. The reviewer also said that the PI should consider how key insights predicted by the model, for example, that PHEVs sold well because of faster acceleration and low-cost electricity source. This could be validated or at least reinforced by consumer surveys or other evidence to build confidence in the model.

Reviewer 6:

The reviewer asked why U.S. Environmental Protection Agency (EPA) GHG vehicle regulations, which are aligned with but credited differently than CAFE, are not included. The reviewer asked where other regulations, such as Zero Emission Vehicle (ZEV), Renewable Fuel Standard (RFS), Low Carbon Fuel Standard (LCFS), etc., are in the model. The effect that these parallel and overlapping regulations have is significant in terms of technologies contributing to compliance. The reviewer said that the presentation notes CAFE and GHG, but predominantly talks about CAFE, and seems to treat them as the same, but they are not. For example, diesel helps more with CAFE than GHG.

The reviewer also said a clearer explanation of the type of the logistic regression (LOGIT) model used would greatly benefit the review process and general understanding of the approach, strengths, weaknesses, and limitations of the model. In addition, the reviewer asked if attribute bundles and clusters are considered. Literature suggests or has demonstrated the importance of this type of analysis. The reviewer added that the PI answered a question on this, but acknowledged a gap. A lot of emphasis has been on trying to make the model precise or improve its apparent predictive power, but there was not much discussion on important sensitivities or relationships. For example, the reviewer said, the fact that the PHEV sold well seems to give some insight within a narrow type of vehicle within a given nest, but the reviewer expressed a desire to know how these attributes affect platform switching and consumer preference. In addition, the reviewer stated that, as with all models like this, empirical calibration is good, but caution is always warranted since if the behavior changes, it may not predict the future well. Overprescribing to achieve a better fit to historical data may work against the predictive power of the model moving forward.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer stated that there was an excellent representation of consumer diversification and product choices in the market. Diagnostic capabilities provide interesting insights on model results.

Reviewer 2:

The reviewer noted that there was technically excellent new progress. Better output display, validation, and the improved interface are always steps forward. The reviewer asserted the importance of the added CAFE and GHG accounting, and fuel cell vehicles refueling. Regionality and mid-level blend fuel prices, etc., are also useful improvements.

Reviewer 3:

The reviewer stated that there was an emphasis on addressing consumer heterogeneity to improve substitution patterns, which is valuable. Discussion on understanding the results is solid. The reviewer added that the scenario comparison is useful to understand trends or primary drivers and key sensitivities to changes, but presented work falls short in discussing how to use the output.

Reviewer 4:
The reviewer applauded the addition of all the new options which greatly enhance this tool. Also, the reviewer said that the validation of results by looking at past data is great and not done enough on other models.

Reviewer 5:
The reviewer reported that the project has made good progress, especially considering the relatively low amount of funds compared to other VTO Analysis projects of similar scale. Several additional capabilities have been added into the simulations, including consumer preference heterogeneity and compliance with CAFE standards.

Reviewer 6:
The reviewer said that because the barriers and goals were not clearly expressed, it is hard to provide a lot of specific feedback on this question. The model does include all VTO R&D technologies, and the insight chart provides an interesting look into the relative penalties of each offering. The reviewer added that it is hard to say how well one can directly link R&D to vehicle technology in fleets, and therefore, GHG emissions and petroleum reductions, given the long timeline and the other parallel activities on the industry side. This model is also missing impacts of the ZEV mandate proposed for FY 2016.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:
The reviewer said that the collaboration with industry and government partners led to improvement in the model as well as understanding and confidence in the results.

Reviewer 2:
The reviewer commented that the project has several collaborators representing OEMs, national laboratories, consulting companies and one university partner.

Reviewer 3:
The reviewer commented that the slide on collaboration was in the deck but not covered during the presentation. Consequently, it is hard to evaluate fully or properly. The reviewer added that limiting the collaboration to what some call the domestic manufacturers, such as Ford, GM, and Fiat Chrysler, limits the perspective substantially. European and Asian manufacturers should be part of the collaborative effort as different market shares for platforms and technology approaches do exist, and it is also unclear what each collaborator provides.

Reviewer 4:
The reviewer commented that there are other vehicle choice models, including NHTSA and the Volpe Model that is used for CAFE modeling and rulemaking and other choice models developed by universities such as Massachusetts Institute of Technology. It seemed the collaboration is more up front and/or results benchmarking with the various other choice models is important, but currently missing. For example, the reviewer asked if the results are the same, and why they are different. In addition, the reviewer asked how the models are built differently, and if these differences are deliberate or accidental.

Reviewer 5:
The reviewer indicated that there was not a lot of collaboration, but there was good cooperation with other laboratories for benchmarking. The reviewer added that as suggested elsewhere, collaboration or benchmarking with the EPA or NHTSA models would be instructive.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer pointed out that adding heavy-duty vehicles is a major expansion at this level of completion of the project. The other items are quite enough, but more on infrastructure challenges would be useful.

Reviewer 2:

The reviewer stated that there are modest but important improvements on the horizon for FY 2016. Data visualization innovation seems to have a gap so that customers can really pull out a much richer set of conclusions from the data.

Reviewer 3:

The reviewer reported that the proposed future work is well aligned with the reviewer's suggestions for the project (i.e., incorporating the ZEV mandate and understanding consumer choice aspects related to EV charging infrastructure impacts). Nonlinear preferences with regard to vehicle range could also be improved by better characterizing the number of vehicles in a household, for example, 100-mile range might be okay for daily commuters who have access to a back-up internal combustion engine (ICE) vehicles or HEVs.

Reviewer 4:

The reviewer commented that adding capability to evaluate tax incentives and infrastructure impacts will provide greater insights.

Reviewer 5:

The reviewer indicated that the future proposed research is planned to add several important features to the simulations, including start-stop, CNG vehicles, connected and autonomous vehicles, policy incentives and mandates in different regions, learning curves, and neighbor effects. In addition to these features, the PI should consider including additional methods of improving the efficiency of spark ignition (SI) engine vehicles, for example, gasoline direct injection (GDI), cylinder deactivation, dual clutches, and continuously variable transmissions, especially considering the importance of SI efficiency to the estimated adoption of advanced powertrains as predicted by other VTO Analysis projects. The reviewer added that the proposed future work could also include a plan for communicating key insights from the simulations to decision makers other than DOE.

Reviewer 6:

The reviewer said that the topics seem reasonable, but details are inadequate to permit full evaluation.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer reported that vehicle technology and choice are important in understanding the penetration of efficient vehicles and the subsequent reduction in petroleum consumption.

Reviewer 2:

The reviewer observed that understanding how DOE targets influence actual petroleum and GHG reduction goals is critical to informing the choice of targets so they are most effective. This model is also providing a very useful capability to understand how the interaction between DOE targets and other policies, for example, CAFE and ZEV, affects end goals.

Reviewer 3:

The reviewer noted that if the model is used properly, or results are used properly, they can provide guidance into strategic direction and investment or contribute to understanding them.

Reviewer 4:

The reviewer commented that the model includes all VTO R&D targets and can be used to assess overall contribution to petroleum reduction.

Reviewer 5:

The reviewer suggested that the project team should understand consumer choices and the interaction with CAFE that can inform energy and transportation policy decisions that would ultimately displace petroleum.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer noted that the project is progressing very well with the current level of funding, even though it is relatively low compared to other VTO Analysis projects of similar scope. Additional funds may be warranted to increase the scope of future research to include additional capabilities and improve validation of the simulations.

Reviewer 2:

The reviewer stated that this model provides an interesting and unique approach to modeling consumer behavior, one that many stakeholders could use and employ. Given that, continued funding and support of the planned updates and development activities is recommended.

Reviewer 3:

The reviewer commented that the budget seems to be a reasonable allocation given the current and proposed scope of work.

Consumer-Segmented Vehicle Choice Modeling: the MA3T Model: Zhenhong Lin (Oak Ridge National Laboratory) - van005

Presenter

Zhenhong Lin, Oak Ridge National Laboratory.

Reviewer Sample Size

A total of six reviewers evaluated this project.

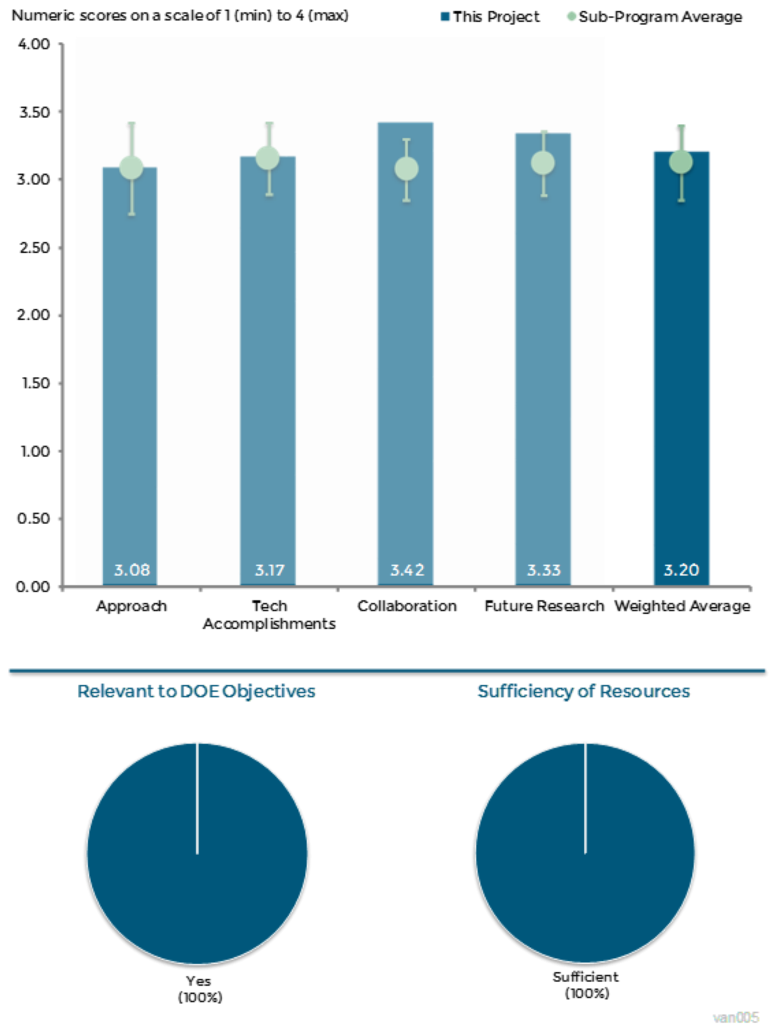


Figure 9-5 Consumer-Segmented Vehicle Choice Modeling: the MA3T Model: Zhenhong Lin (Oak Ridge National Laboratory) – Vehicle Analysis

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

Reviewer 1:

The reviewer remarked that the project incorporates many factors that are important to understanding barriers to PEV adoption, including recharging infrastructure, state incentives, travel patterns, energy prices, and household vehicle usage behavior. Systematic calibration and validation is also included in past and future work plans. The reviewer added that the effort seems well integrated with other VTO Analysis projects. The approach would benefit from a comparison of the model with other analysis methods and results.

Reviewer 2:

The reviewer indicated that investigating vehicle choice using LOGIT is a valuable approach, and validation is useful, but now that there are multiple SI vehicles, validation could be more comprehensive.

Reviewer 3:

The reviewer commented that the project team had a very comprehensive approach to addressing consumer choice.

Reviewer 4:

The reviewer said that the model estimates market acceptance and sales as a function of technology, infrastructure, consumer behavior, and policy factors. The barriers addressed are cost of advanced powertrains and behavior of manufacturers and consumers. The reviewer added that a large emphasis in FY 2015 has been on improvements to and validation of model in several ways. As identified by the PI, understanding supply-side and consumer behavior could be improved, and furthermore, the model could examine the impact of infrastructure on consumer's decision to buy an alternative fuel vehicle (AFV).

Reviewer 5:

The reviewer noted that at first glance, it seems there is overlap in the inputs and outputs of this model and others within VTO. Certainly this conclusion could be incorrect, but would suggest highlighting how all the various models are different and the same. The reviewer added that the project would bolster confidence that there is an overall cohesive modeling strategy. At a minimum, for all of these models, it might be helpful to have a Simulink-like box showing the inputs and outputs at the beginning.

Reviewer 6:

The reviewer reported that the dynamic diagram is unclear and fails to capture many of the system relationships and feedbacks. This limits confidence in the output. The reviewer also said conclusions about the Osborne effect are not warranted. This requires actual testing, although other causes such as general market saturation could be at play. The reviewer stated that it is unwarranted to make the conjecture at this time. Work to date did not show sensitivity analysis or discuss; the listed future work demonstrates why this is important. The reviewer noted that the researcher does not seem familiar with much of the market/technology diffusion modeling or theory. There was a lack of transparency in the model as presented or included in the slide deck. Given that structure leads to behavior, this needs to be resolved or addressed. The reviewer also said that for the model to be useful, the structure needs to capture the relevant interactions and the underlying consumer choice models, other inputs, and underlying mathematical mechanics need to be robust. More value would be derived from exploring the why, rather than what happened.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer stated that the project has made good progress, including the incorporation of state-level analysis, battery electric vehicle (BEV) range uncertainty and utilization, and increased transparency of all modeling inputs. Systematic validation tests will be an important future contribution.

Reviewer 2:

The reviewer stated that the work captures key elements and dynamics associated with consumer choice and behavior.

Reviewer 3:

The reviewer noted that the project seems on track to meet project goals. Validation on multiple levels increases confidence in tool’s utility. The reviewer stated that the main concern with validation sounds like the so-called Osborne Effect, where sales are flat-lining when a new model is announced. This effect is probably especially pronounced with respect to PEVs because a new model often corresponds to a significant performance improvement. The reviewer added that another effect that has been very noticeable in 2015 is dealerships offering deeply discounted BEV leases to ensure that the manufacturer meets its ZEV credit goals. Fiat is an example.

Reviewer 4:

The reviewer pointed out that the project team should have done validation a while ago, but wondered why the project team cannot capture extended range electric vehicle (EREV)-40. Either the PI misheard or this probably should be added. State policies seem hard to capture with so few vehicles. Multiple SI vehicles were also finally added.SI vehicles.

Reviewer 5:

The reviewer commented that it seems there is confusion between verification and validation. Verification is often referred to as did you build it right, whereas validation is did you build the right thing. The reviewer had the sense that validation was being used to say that the model calculates properly and does not have any major errors, etc., which is verification, not validation. Validation is more about the perceived accuracy of the results compared to what it is really desired to measure. For example, if there is a 5% market share for EVs in 2020 based on a number of inputs, then one would expect that in 2020 the team for this model will check how well they predicted this at that time. At the same time, these predictions have certainly been made for years, yet a slide on how accurately the model created in 2010 predicted the 2015 market share could not be seen. Validation can also be used against other models that attempt to produce the same output. The reviewer added that although this is not as robust as the first method, it is still a form of testing whether the right thing was built. A third method is to poll consumers of the model as to its usefulness and accuracy. The reviewer also said that this is another way of validating the right thing was built. On a final thought, validation is often not recommended to be completed by the model builder, which is why Underwriters Laboratories (UL) and so many third party agencies, certify safety-related models and equipment.

Reviewer 6:

The reviewer reported that the results shown were limited, and it would be beneficial to see some scenarios and how the researcher analyzes or draws conclusions from them.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer remarked that the project has an excellent set of collaborators, including an OEM, several universities, and national laboratories.

Reviewer 2:

The reviewer observed strong collaboration with many different stakeholders and agencies.

Reviewer 3:

The reviewer noted that because other researchers such as International Institute for Applied Systems Analysis (IIASA) are trying to adapt the model, is a vote of confidence in the modeling and approach. Peer-reviewed papers are well cited.

Reviewer 4:

The reviewer stated that there was a fairly broad collaboration and coordination, but suggested at least bringing in DOT.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer reported that the future work does seem comprehensive, with some useful features on the way, such as incentives modeling, but the PI could consider expanding beyond just charging EVs and possibly refueling in general, for example, hydrogen (H_2) refueling time versus range as compared to EVs.

Reviewer 2:

The reviewer stated that the proposed future work seems reasonable, but would recommend that if the PI plans to investigate more regional analysis of consumer preference for BEV size (for example, LEAF versus Tesla in Michigan) the model be expanded to include climate as well as an estimate of PHEV and BEV battery range as a function of outdoor temperature.

Reviewer 3:

The reviewer commented that the future work plans cover many important areas of development for the model, including systematic validation, additional supply-side behavior, and sensitivity analyses. The incorporation of conventional vehicles that are competing with PEVs, particularly high-efficiency vehicles, will be an important contribution. The reviewer also noted that the model would benefit from the addition of advanced SI vehicle technologies (e.g., HEVs, exhaust gas recirculation (EGR), dual clutches, and continuously variable transmissions (CVTs)). There are several possible explanations for flat sales of the Volt other than the Osborne effect, such as decreases in gasoline prices. The reviewer added that it would be helpful to perform further validation tests and systematically examine the model to verify the Osborne effect before incorporating it into the model.

Reviewer 4:
The reviewer indicated that the increase in NG technologies should be timely and systematic validation should be useful. The reviewer added that the multi-vehicle households are emphasized, primarily for BEV and PHEV markets, which is also timely.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer remarked that the project is an excellent tool for evaluating potential market penetration of advanced technologies.

Reviewer 2:
The reviewer stated that knowing consumer acceptance of various charging scenarios is important in shaping future product plans and predicting acceptance of EVs in the future.

Reviewer 3:
The reviewer reported that the vehicle choice is critical in understanding penetration of AFVs, which reduce petroleum consumption.

Reviewer 4:
The reviewer noted that this model can be used to identify potential technology, infrastructure, consumer marketing and outreach, and policy methods that may be more successful in promoting AFV sales.

Reviewer 5:
The reviewer commented that examining the influence of refueling and recharging infrastructure, regulations, and incentives on the penetration of PEVs is important to inform VTO decisions of what targets to set and where to concentrate their efforts to most effectively achieve reductions in petroleum use and GHG emissions.

Reviewer 6:
The reviewer said that yes, the work supports DOE objectives, but a significant opportunity for improvement exists.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer said that the amount of resources seems about the right level given the model.

Reviewer 2:
The reviewer reported that the budget seems to be a reasonable allocation given the current and proposed scope of work.

Reviewer 3:
The reviewer stated that the project funds are higher than several other VTO Analysis projects, but the project's past and future work plan includes a substantial level of depth in calibration, validation, and state-specific analysis, which justifies the higher funding level.

Parametric Vehicle Choice Modeling: ParaChoice: Dawn Manley (Sandia National Laboratories) - van014

Presenter

Dawn Manley, Sandia National Laboratories.

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

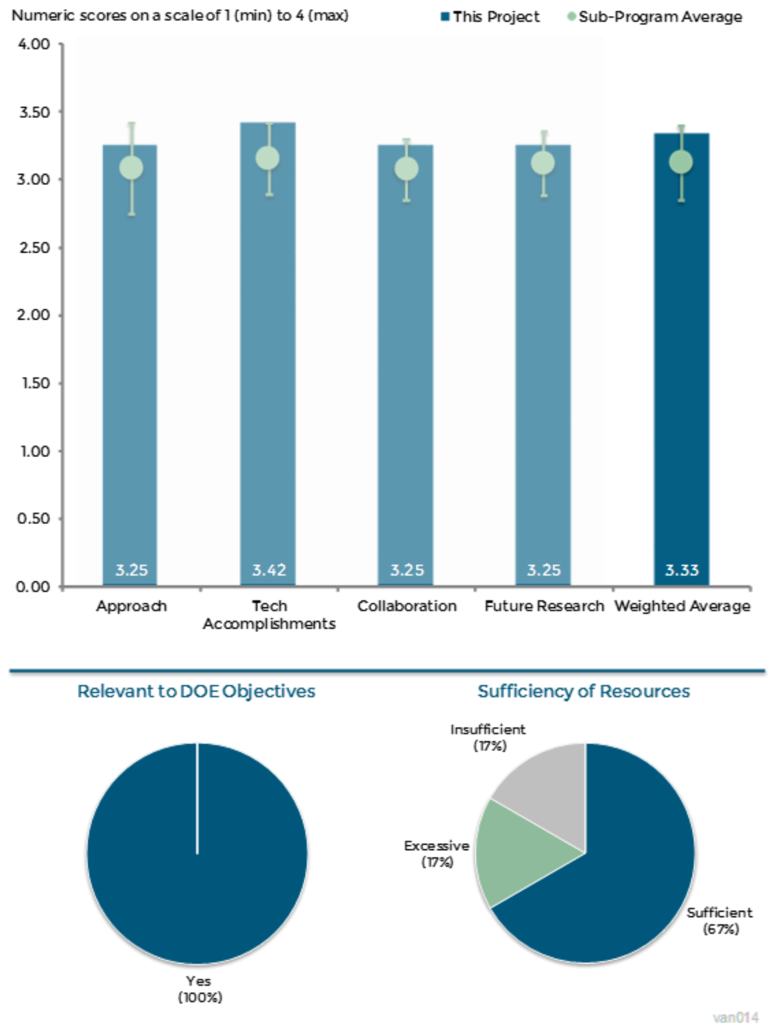


Figure 9-6 Parametric Vehicle Choice Modeling: ParaChoice: Dawn Manley (Sandia National Laboratories) – Vehicle Analysis

Reviewer 1:

The reviewer commented that the approach is good, and it is just going to take time and continued iteration to overcome more barriers. The reviewer was unsure whether there were any deficiencies in the approach, though at this stage, the complexity and breadth provide some limits to the ability to overcome all of the VTO program barriers. The reviewer added that the project team had a logical approach to the study and model.

Reviewer 2:

The reviewer observed that the first very positive aspect of the approach was soliciting feedback from Toyota and Ford as well as convening a workshop in advance. This type of activity should be at the heart of the beginning of every model endeavor to understand the customer. The reviewer added that the second very positive aspect is how clearly articulated the approach was of using the outputs of all the other various models from the VTO portfolio, then processing and aggregating the results, where the potential here is very powerful.

Reviewer 3:

The reviewer reported that the project team had an interesting approach to defining and quantifying potential market share trade-offs between critical model parameters including vehicle attributes, tax incentives, etc.

Reviewer 4:

The reviewer stated that the project approach was to hold stakeholder engagement workshops and conduct parametric analysis to address uncertainty associated with vehicle adoption and identify sensitivities and tipping points. Barriers addressed include the availability of alternative fuel, charging infrastructure, and vehicles, the uncertainty in vehicle choice models and projections, identifying leverage points for reducing petroleum consumption, and GHG emissions. The reviewer added that the approach is well suited to address modeling uncertainties and identifying scenarios that might be more successful in promoting AFVs and reducing petroleum use and GHG emissions. The reviewer commented that it was unclear how the workshop that was held on NG and H_2 translated into the ParaChoice model development, and asked if this was an input to the model. Perhaps this was discussed in the parallel H2-focused presentation, but it was unclear from this presentation.

Reviewer 5:

The reviewer said that the parametric analysis provides useful insights that can guide VTO decisions and those of other stakeholders, but validation of the various parts of the model and input assumptions could be improved. For example, the assumptions of vehicle miles traveled (VMT) and vehicle growth rate per capita do not follow historic trends. The reviewer added that many more validation tests could also be performed for the logit model, including matching predicted sales of SI and compression ignition (CI) vehicles with historical data.

Reviewer 6:

The reviewer indicated that there was a very broad focus that included models, energy supply, vehicles, powertrains, VMT, and demographics. The reviewer added that this seems to be a great deal for one model.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer stated that the project has made good progress since it was started last year. Several parametric analyses were conducted and multiple validation tests were performed with the results.

Reviewer 2:

The reviewer reported that interesting insights were provided on a variety of factors effecting market share trade-offs between variation in gas-SI and plug-in vehicle performance, infrastructure development, and cost.

Reviewer 3:

The reviewer pointed out that the results emphasize learning and insights, versus absolute answers. The results and analysis are clearly presented; this should be continued moving forward. The reviewer added that one area not covered for PHEVs and charge sustaining is the effect of high-occupancy vehicle (HOV) lane sticker access. One area that could improve the value is to conduct (or show) more sensitivity and uncertainty analysis on what the research identifies as the most influential factors or relationships. The reviewer commented that this was covered in Q&A, but not shown in the results for this extends beyond the PHEV-10 versus PHEV-40 shown as backup.

Reviewer 4:

The reviewer commented that back casting has resulted in a close match between model outputs and historical data for hybrid sales. The reviewer recommended digging deeper into the relationship between infrastructure and BEV and PHEV attractiveness, but was unclear whether the model includes different electric vehicle supply equipment (EVSE) power levels. The addition of direct-current (DC) fast charging, as well as Level-2 public charging, could make a significant difference among the non-single-family market. The reviewer added that finding that the access to one hour of public charging increases PHEV attractiveness is interesting, but also surprising. The reviewer also recommended doing a deep dive into this result, especially with regard to the cost of public charging. PHEVs on the road today do not typically charge at public stations unless it is free.

Reviewer 5:

The reviewer commented that confusion over verification versus validation persists here, similar to the Market Acceptance of Advanced Automotive Technologies (MA3T) model. Verification is expressed as whether one built it right, and validation is expressed as whether one built the right thing. The reviewer added that in this presentation, both were actually demonstrated. One validation method used was comparison to other models, whereas validation can also be employed through surveys of customers and users to ensure the results are useful and beneficial to them. The reviewer said that a third method is to see if prior models successfully predicted what has happened today. Also, while the point that this model is not for predicting the future is understood, it is a little disingenuous. The reviewer said clearly that these models are for predicting different future scenarios based on a set of inputs at a minimum, and it should predict the future, plus or minus some uncertainty, if the inputs known at the time are correct. The observed very interesting results and a useful model.

Reviewer 6:

The reviewer noted that the validation was based on a very short time period with few vehicles sold. CNG seemed to be over-emphasized. The reviewer added that assumptions on S-curve for technology are hard to calibrate, as are the infrastructure build-out assumptions.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer said the project team has excellent peer reviews and wide collaborations.

Reviewer 2:

The reviewer commented that as part of the project, the PI convened a workshop to engage a variety of stakeholders and receive input on the simulation methodology. Multiple OEMs and national laboratories are included as partners. The reviewer added that it would be helpful to add university partners that have experience with choice model validation as well as with comparable models of the fueling infrastructure.

Reviewer 3:

The reviewer stated that there was collaboration with an OEM – Ford– as well as model input, review, and critiques from agencies and other stakeholders.

Reviewer 4:

The reviewer reported that the PI uses modeling information from various sources, but does not have much collaboration with other organizations.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:

The reviewer stated that the future work was well defined and addresses appropriate issues.

Reviewer 2:

The reviewer said that the researcher clearly understands the limitations and weaknesses of the model and has articulated clear actionable items to address with appropriate expectations on what the improvements will provide, where the challenges in executing the improvements are understood. The reviewer could offer no real substantive critique or suggestion for improvement.

Reviewer 3:

The reviewer stated that one piece missing from future work is improvement to data visualization. While the graphic produced for this product did outperform other project, which is great, the reviewer believed even these could become more compelling with, for example, animated graphs (that pivot, rotate, or change in time), or the many other emerging methods. The reviewer added that a second area would be a tornado chart quantifying the relative sensitivities of the outputs to the inputs, as this could be at least as valuable as the graphs already produced. Otherwise, the future plans look solid.

Reviewer 4:

The reviewer recommended inclusion of the ZEV mandate as an additional policy input to the model. Overall, the proposed future research is thoughtfully planned out. The reviewer added that it does seem that including heavy-duty vehicles would require major updates to the model which could exceed available resources. The reviewer looked forward to seeing comparative results between ParaChoice and other VTO Analysis models in the future.

Reviewer 5:

The reviewer commented that the proposed future research addresses uncertainty in vehicle choice models, comparison of results and approach with similar models, and the inclusion of heavy-duty vehicles, which are welcome additions. Further validation by comparing results to historical data of the various pieces of the model should also be included, for example, the vehicle choice model and the influence of infrastructure availability and fuel demands.

Reviewer 6:

The reviewer reported that adding heavy-duty vehicles seemed to extend the scope significantly on an already-expansive model. Issues related to infrastructure are important and timely. The reviewer also said that comparison to other models is definitely valuable.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:

The reviewer commented that this project goes beyond typical sensitivity analysis of vehicle choice models. When completed, the model should provide robust indicators regarding different technologies and policies that are tipping points when it comes to AFV adoption.

Reviewer 2:

The reviewer commented that understanding and aggregating the output of the other models that also work to displace petroleum, would also displace petroleum.

Reviewer 3:

The reviewer reported that understanding how various parameters, such as battery costs and SI efficiency, influence the transition to alternative vehicles, will help DOE target the mechanisms that are most effective to reduce petroleum use.

Reviewer 4:

The reviewer indicated that the project directly addresses petroleum consumption through evaluation of technology programs.

Reviewer 5:

The reviewer stated that results may not have been what some wanted or expected, but they are insightful and can help inform technology deployment and development.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:

The reviewer said that for $100,000, this project was a bargain, but that DOE may want to consider increased funding in the future.

Reviewer 2:

The reviewer stated that the budget seems to be a reasonable allocation given the current and proposed scope of work.

Reviewer 3:

The reviewer indicated that the funding level is comparable to other VTO Analysis projects of similar scope.

Reviewer 4:

The reviewer thought this project is premature. As the consumer gets more alternative vehicles this model can be empirically calibrated. The reviewer added that, as it stands, exhaustively enumerating possibilities does not seem to help a policy-maker when there is so much uncertainty.

PEV Consumer Behavior in Practice (PCBIP): Mike Nicholas (University of California, Davis) - van015

Presenter

Mike Nicholas, University of California, Davis.

Reviewer Sample Size

A total of six reviewers evaluated this project.

Question 1: Approach to performing the work—the degree to which technical barriers are addressed, the project is well-designed, feasible, and integrated with other efforts.

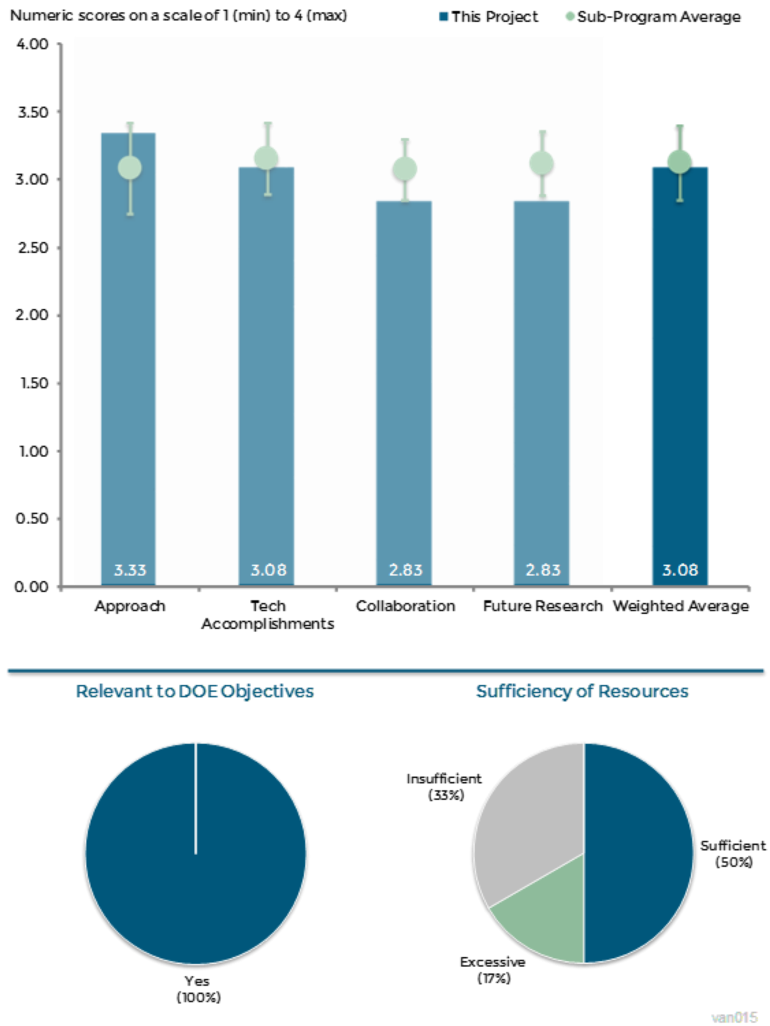


Figure 9-7 PEV Consumer Behavior in Practice (PCBIP): Mike Nicholas (University of California, Davis) – Vehicle Analysis

Reviewer 1:

The reviewer commented that there was an excellent approach to better understanding the utilization of battery powered vehicles in single- and multi-vehicle households.

Reviewer 2:

The reviewer noted that there was an excellent use of collaboration and that there were relatively large samples.

Reviewer 3:

The reviewer stated that electric vehicle miles traveled (eVMT) is an important metric to explore. The project could just focus on this issue, the reviewer said, but added that the presenter did not effectively cover existing literature, for example, Zoepf and more, that explored consumer charging behavior. Combining the OEM and survey data sets is good. The reviewer questioned the significance of the data given the sample size and breadth of metrics. The presenter articulated some interesting questions, but they need to be clearly articulated in the presentation as part of what is motivating the research. The reviewer asked how the project team drove the research. This was not an easy project to evaluate, the reviewer found, as the presenter was disorganized and was unable to fully or properly present the material.

Reviewer 4:

The reviewer stated that the project seeks to address the barriers of infrastructure and constant advances in technology through a 37,000- person survey as well as vehicle data collection in 144 households over the course of one year. The travel data is examined at the household level and covers households with most major PEV categories. The reviewer added that shorter time frames may miss long, infrequent trips that are the primary contributor to annual VMT. The project seems well-designed and the resulting dataset will be incredibly valuable. The reviewer also said the project could be improved by the inclusion of some non-PEV households for comparison.

Reviewer 5:

The reviewer reported that this project makes a very good contribution to understanding BEV adoption and usage by collecting detailed data at the household level. The household sample was carefully selected to approximate a representative set. The reviewer added that the possibility of monitoring or inferring who in the household is driving the vehicles would be an important addition, which should be considered carefully when collecting future data.

Reviewer 6:

The reviewer noted that the shift between PHEVs, BEVs and ICEs does seem very relevant to explore, and eVMT is an important metric to explore. This reviewer further commented that the presenter was thrown a bit by having a different presentation than anticipated, which may or may not have been the presenter's fault.

Question 2: Technical Accomplishments and Progress toward overall project and DOE goals—the degree to which progress has been made, measured against performance indicators and demonstrated progress towards DOE goals.

Reviewer 1:

The reviewer stated that the analysis is sound and demonstrated progress is strong even though a complete year of household data is not yet available, and noted that collecting household-level data of this scale takes considerable time and effort.

Reviewer 2:

The reviewer noted that a lot of analysis is left on the table. A good first start would be comparing the shifting between the LEAF and the PHEVs. The reviewer added that work is not at a sufficient stage of completeness to permit adequate evaluation.

Reviewer 3:

The reviewer explained that work has a narrow focus and is well developed. The household as unit of data and data collection by vehicle seems very timely, but the project team will not be able to compare households with two ICEs, which is something of a disadvantage.

Reviewer 4:

The reviewer said that this project is at a little too early stage for accomplishments but preparatory analysis was presented using an existing one-week dataset from Caltrans with just LEAF households. Although all vehicle use in a household is tracked, it is not a planned capture that members of the household are driving each vehicle, for this could be a useful metric to understand differences in weekday and weekend travel behavior within a household.

Reviewer 5:

The reviewer commented that the project is in the data collection phase, but the presentation did not reflect that.

Question 3: Collaboration and coordination with other institutions.

Reviewer 1:

The reviewer commented that the dataset will be available to NREL, ORNL, and ANL, and some related coordination has been initiated. Given the size of the eventual dataset, the reviewer recommended early collaboration on formatting of the final delivered dataset to eliminate wasted time and parallel work. The reviewer said thus far, besides CARB, there does not seem to be a lot of collaboration with other institutions.

Reviewer 2:

The reviewer pointed out that the project team leverages other data and programs.

Reviewer 3:
The reviewer stated that the collaboration and coordination did seem adequate, though a little bit more detail as to how the collaboration is happening, would have been helpful.

Reviewer 4:
The reviewer said that the data is obviously coming from a collaborator, but the collaborations that could help in the analysis appear to be non-existent. For example, Don McKenzie, from the University of Washington, has a far more proven capability and experience in developing the mathematical analysis and models to describe the behavior.

Reviewer 5:
The reviewer indicated that this project has no OEM partners nor university partners. Increasing this collaboration would be beneficial to cross-validate results with OEM insights and academic research.

Question 4: Proposed future research—the degree to which the project has effectively planned its future work in a logical manner by incorporating appropriate decision points, considering barriers to the realization of the proposed technology, and, when sensible, mitigating risk by providing alternate development pathways.

Reviewer 1:
The reviewer indicated that the important future challenges to the work are identified and sensible approaches, including automatic data cleaning, are proposed that will be a good contribution to further the work. The reviewer would have liked to see a more detailed explanation of how the team will collect information on driver identification and how selection bias can be dealt with so that the analysis can provide useful interpretations of miles shifted between ICE vehicles and the LEAF.

Reviewer 2:
The reviewer noted that the goals to complete the project and log data for all households are logical next steps.

Reviewer 3:
The reviewer reported that the future research seemed fairly straightforward and adequate, but nothing more ambitious.

Reviewer 4:
The reviewer stated that not a lot of detailed information was given on future work in the presentation, and gathered that the future work is to execute the survey as planned with timeline provided, and to analyze the results.

Reviewer 5:
The reviewer said that almost no information on planned future work was given by the PI.

Question 5: Relevance: Does this project support the overall DOE objectives of petroleum displacement? Why or why not?

Reviewer 1:
The reviewer stated that quantifying and predicting eVMT is an important gap to fill and will certainly inform future choices that maximize the likelihood of displacing petroleum.

Reviewer 2:
The reviewer commented that in theory, yes, the work supports DOE objectives especially with regard to how eVMT could enhance petroleum reduction overall. As this project is expected to wrap up in FY 2016, the reviewer expressed hope it can address the shortcoming to date. If not, the reviewer said that fudging should not be continued, especially beyond FY 2016 and alternative entities to execute the research should be sought.

Reviewer 3:
The reviewer observed that this project will provide a dataset to characterize eVMT in a diverse range of households. This will help inform many other modeling efforts in the VTO.

Reviewer 4:
The reviewer indicated that understanding household level behavior of BEV adoption and use is important to inform BEV targets and infrastructure decisions.

Reviewer 5:
The reviewer noted that how people use BEV will inform all later modeling on consumer choice.

Question 6: Resources: How sufficient are the resources for the project to achieve the stated milestones in a timely fashion?

Reviewer 1:
The reviewer commented that the financial resources are sufficient. There is uncertainty or a lack of confidence that the technical resources are sufficient for reasons noted in the collaboration with others.

Reviewer 2:
The reviewer noted that while the FY 2015 funds are relatively high compared to other VTO Analysis projects, the household-level data that this project provides is difficult to obtain and warrants the current level of support.

Reviewer 3:
The reviewer pointed out that more emphasis should be on this project and its type, and less on the generic consumer survey.

Reviewer 4:
The reviewer reported that in a way, this project was tough to assess because the presentation was not correct and this threw the presentation off a bit. However, as valuable as this work is, the resources do seem like a lot for what has been delivered.

Reviewer 5:
The reviewer’s concern was that the data cleaning activity, already identified as a risk, will exceed the resources available.

Acronyms and Abbreviations

AFV	Alternative fuel vehicle
ANL	Argonne National Laboratory
BEV	Battery electric vehicle
CAFE	Corporate Average Fuel Economy
CI	Compression ignition
CNG	Compressed natural gas
CVT	Continuously variable transmissions
DC	Direct current
DOE	Department of Energy
DOT	Department of Transportation
EERE	Office of Energy Efficiency and Renewable Energy
EGR	Exhaust gas recirculation
EPA	Environmental Protection Agency
EREV	Extended range electric vehicle
EV	Electric vehicle
eVMT	Electric vehicle miles traveled
EVSE	Electric vehicle supply equipment
FCEV	Fuel cell electric vehicle
FY	Fiscal year
GDI	Gasoline direct injection
GHG	Greenhouse Gas
GREET	Greenhouse Gas, Regulated Emissions, and Energy Use in Transportation
H_2	Hydrogen
HEV	Hybrid electric vehicle
HOV	High-occupancy vehicle
ICE	Internal combustion engine
ISO	International Organization for Standardization

LCA	Life cycle assessment
LCFS	Low-carbon fuel standard
LOGIT	Logistic regression
MA3T	Market Acceptance of Advanced Automotive Technologies
MY	Model year
NG	Natural gas
NHTSA	National Highway Traffic Safety Administration
NREL	National Renewable Energy Laboratory
OE	Department of Energy Office of Electricity Delivery and Energy Reliability
OEM	Original Equipment Manufacturer
ORNL	Oak Ridge National Laboratory
PHEV	Plug-in hybrid electric vehicle
PI	Principal investigator
Q&A	Questions and answers
R&D	Research and development
RFS	Renewable Fuel Standard
SI	Spark ignition
SNL	Sandia National Laboratories
VAN	Vehicle Analysis
VMT	Vehicle miles traveled
VTO	Vehicle Technologies Office
ZEV	Zero emission vehicle

10. Acronyms

1D	One dimensional
3D	Three dimensional
A/C	Air-Conditioning
ABR	Advanced Battery Research
AC	Alternating current
ACE	Advanced combustion engine
ACEC	Advanced Combustion and Emissions Control
ADP	Advanced drying process
AEC	Automotive Electronics Council
AEC	Advanced Engine Combustion
AFCI	Advanced Fuel Cycle Initiative
AFDC	Alternative Fuels Data Center
AFR	Air to fuel ratio
AFV	Alternative fuel vehicle
Ah	Ampere-hour
AKI	Anti-knock index
Al	Aluminum
ALD	Atomic Layer Deposition
AlF_3	Aluminum fluoride
AMR	Annual Merit Review
ANL	Argonne National Laboratory
APEEM	Advanced Power Electronics and Electrical Machines
API	Application programming interface
APM	Analog power module
APRF	Advanced Powertrain Research Facility (ANL)
APS	Advanced photon source
APU	Auxiliary Power Unit

ARK	Abuse Reaction Kinetics
ARL	Army Research Lab
ARPA-E	Advanced Research Projects Agency - Energy
ARRA	American Recovery and Reinvestment Act
ASTM	American Society for Testing and Materials
ATF	Automatic transmission fluid
ATR	Attenuated Total Reflectance
Au	Gold
AVFL	Advanced Vehicle/Fuel/Lubricants
AVTA	Advanced Vehicle Testing Activity
AVTE	Advanced Vehicle Testing & Evaluation
BATT	Batteries for Advanced Transportation Technologies
BES	Office of Basic Energy Sciences
BEV	Battery electric vehicle
BIM	Bonded interface material
BIW	Body in white
BL	Boundary lubrication
BMEP	Brake Mean Effective Pressure
BMR	Battery Materials Research
BMS	Battery Management System
BNL	Brookhaven National Laboratory
BP	Budget period
BP	Bandpass
BSFC	Brake-specific fuel consumption
BSG	Belt-Driven Starter-Generator
BTE	Brake thermal efficiency
C	Carbon
C	Centigrade

Ca	Calcium
CAD	Computer-aided design
CAE	Computer-aided engineering
CAEBAT	Computer-aided engineering of batteries
CAFE	Corporate average fuel economy
CAMP	Cell Analysis, Modeling, and Prototyping
CARB	California Air Resources Board
CCC	Co-precipitated CuO_X, CoO_y, and Ceo_2 catalyst
CCV	Cycle-to-cycle variability
CDC	Conventional diesel combustion
CEC	California Energy Commission
CEI	Cathode electrolyte interphase
CF	Carbon fiber
CFC	Carbon fiber composite
CFD	Computational fluid dynamics
CG	Concentration gradient
CGI	Compacted graphite iron
CH_4	Methane
CHA	Chabazite
CI	Compression ignition
CIC	Communications, information, and communication
CLEERS	Cross-Cut Lean Exhaust Emission Reduction Simulation
CMC	Carboxymethyl Cellulose
CN	Cetane number
CNG	Compressed natural gas
CNT	Carbon Nanotubes
CNT	Carbon Nanotubes
CO	Carbon Monoxide

Co	Cobalt
CO	Carbon Monoxide
CO_2	Carbon dioxide
COV	Coefficient of variance
CPES	Center for Power Electronics Systems
CPT	Capacitive power transfer
CPU	Central processing unit
Cr	Chromium
CR	Compression ratio
CRADA	Cooperative Research and Development Agreement
CRAFT	Complete Reduction to Amplitude Frequency Table
CRC	Coordinating Research Council
CRF	Combustion Research Facility
CSC	Cold Start Concept
CSTR	Continually stirred tank reactor
CT	Computed tomography
CTE	Coefficient of thermal expansion
Cu	Copper
CVT	Continuously variable transmission
CY	Calendar year
CZ	Ceria-zirconia
dBA	Decibel
DBC	Direct bonded copper
DC	Direct current
DCN	Derived cetane number
DCR	Direct current resistance
DCT	Dual-clutch transmission
D-EGR	Dedicated-Exhaust Gas Recirculation

DFT	Density functional theory
DI	Direct Injection
DISI	Direct Injection Spark Ignited
DMF	2,5-Dimethylfuran
DNS	Direct numerical simulation
DOC	Diesel oxidation catalyst
DoD	Depth of discharge
DOD	Department of Defense
DOE	Department of Energy
DOT	Department of Transportation
DOT	Department of Transportation
DPF	Diesel particulate filter
DPP	Dynamic particle-packing
DRG	Diagnosis-related group
DSC	Differential Scanning Calorimetry
DSNY	City of New York Department of Sanitation
DTBP	Di-t-butyl peroxide
DTNA	Daimler Trucks North America
Dy	Dysprosium
E0	0% ethanol blend with gasoline
E10	10% ethanol blend with gasoline
E20	20% ethanol blend with gasoline
E30	30% ethanol blend with gasoline
E85	85% ethanol blend with gasoline
EA	Ethylene acrylic
Ea	Activation energy
EATS	Exhaust after-treatment system
EC	Ethylene Carbonate

ECN	Engine Collaboration Network
ECS	Emission control system
ECT	Electrochemical-Thermal Coupling
ECU	Engine control unit
EDLC	Electrochemical double-layer capacitors
EDM	Electrode domain model
EDS	Energy Dispersive X-ray Spectroscopy
EDT	Electric Drive Technologies
EDV	Electric Drive Vehicle
EELS	Electron Energy Loss Spectroscopy
EERE	Office of Energy Efficiency and Renewable Energy
EETT	Electrical and Electronics Technical Team
EG	Ethylene glycol
EGR	Exhaust gas recirculation
EHN	2-ethylhexyl nitrate
EHR	Exhaust heat recovery
EIA	Energy Information Administration
EIS	Electrochemical Impedance Spectroscopy
EM	Electric motor
EMC	Electromagnetic compatibility
EMI	Electromagnetic interference
EOL	End-of-life
EPA	Environmental Protection Agency
EPR	Electron Paramagnetic Resonance
EPRI	Electric Power Research Institute
EPTO	Electric power takeoff
ERC	Engine Research Center
EREV	Extended range electric vehicle

ESIF	Energy Systems Integration Facility
ESL	Equivalent series inductance
ESR	Equivalent series resistance
ESS	Energy Storage Systems
EU	European Union
EV	Electric vehicle
eVMT	Electric vehicle miles traveled
EVSE	Electric vehicle supply equipment
EXAFS	Extended X-ray Absorption Fine Structure
F	Fluorine
FA	Field Aging
FACE	Fuels for Advanced Combustion Engines
FAME	Fatty acid methyl ester
FBCC	Front bumper and crush can
FC	Fluorocarbon
FC	Fuel cell
FCA	Fiat Chrysler Automobiles
FCEV	Fuel cell electric vehicle
FCG	Full concentration gradient
Fe	Iron
FE	Fuel economy
FEA	Finite element analysis
FEC	Fluorinated ethylene carbonate
FEG	Fuel Economy Guide
FEM	Finite element modeling
FET	Field-effect transistor
FFV	Flex-fuel vehicles
FGM	Flamelet generated manifold

FHWA	Federal Highway Administration
FMEP	Friction mean effective pressure
FOA	Funding Opportunity Announcement
FSP	Friction Stir Processing
FST	Filter sensing technologies
FTE	Full-time equivalent
FTIR	Fourier Transform Infrared Spectroscopy
FTMPG	Freight ton-miles per gallon
FTP	Federal Test Procedure
FY	Fiscal year
g	gram
GaN	Gallium Nitride
GATE	Graduate Automotive Technology Education
GCI	Gasoline compression ignition
GDCI	Gasoline Direct Compression Engine
GDI	Gasoline direct injection
GE	General Electric
GFR	Glomerular filtration rate
GHG	Greenhouse gas
GM	General Motors
GPF	Gasoline Particulate Filter
GPU	Graphics Processing Unit
GREET	Greenhouse Gas, Regulated Emissions, and Energy Use in Transportation
GSA	Global sensitivity analysis
GSF	Generic Speed Form
GTDI	Gasoline Turbocharged Direct Injection
GTR	Global Technical Regulation
H_2	Hydrogen

H_2O	Water
HA	Hydrothermal assisted
HC	Hydrocarbon
HCCI	Homogeneous Charge Compression Ignition
HcJ	Thermal coefficient of coercive force
HCl	Hydrogen chloride
HCMR	High capacity manganese rich
HD	Heavy-Duty
HECC	High efficiency clean combustion
HEDGE	High-Efficiency Dilute Gasoline Engine
HEV	Hybrid electric vehicle
HF	Hydrofluoric acid
HHDDT	Heavy heavy-duty diesel truck
HHV	Hydraulic hybrid vehicle
HIL	Hardware in the Loop
HOMO	Highest occupied molecular orbital
HOV	Heat of vaporization
HOV	High-occupancy vehicle
HPC	High Performance Computing
HR	High-resolution
HRSXRD	High-resolution Synchrotron X-ray Diffraction
HRTEM	high-resolution transmission electron microscopy
HV	High voltage
HVAC	Heating, Ventilating and Air Conditioning
HVE	High-voltage fluorinated electrolyte
HVM	High-volume Manufacturing
ICE	Internal combustion engine
ICL	Initial capacity loss

ICME	Integrated Computational Material Engineering
ICNIRP	International Commission on Non-Ionizing Radiation Protection
ICT	Institute of Chemical Technology
IDT	Ignition delay time
IE	Ion exchange
IEC	International Electrochemical Commission
IEEE	Institute of Electrical and Electronics Engineers
IGBT	Insulated-gate bipolar transistors
IMEP	Indicated mean effective pressure
IMSA	International Motor Sports Association
INL	Idaho National Laboratory
IP	Intellectual property
IPM	Integrated permanent magnet
IQT	Ignition quality tester
IR	Infrared
ISFC	Indicated Specific Fuel Consumption
ISMG	integrated starter motor generators
ISO	International Organization for Standardization
ITE	Indicated Thermal Efficiency
ITS JPO	Intelligent Transportation Systems Joint Program Office
JCESR	Joint Center for Energy Storage Research
JCI	Johnson Controls, Inc.
K	Potassium
kg	Kilogram
kHz	Kilohertz
Kn	Knudsen Number
kV	Kilovolt
kW	Kilowatt

kWh	Kilowatt Hour
L	Liter
La	lanthanum
LANL	Los Alamos National Laboratory
LBNL	Lawrence Berkeley National Laboratory
LCA	Life cycle assessment
LCA	Life-cycle analysis
LCCF	Low-Cost Carbon Fibers
LCFS	Low-carbon fuel standard
LCO	Lithium Cobalt Oxide
LD	Light-duty
LDA	Laser doppler anemometry
LDV	light-duty vehicle
LEESS	Lower-Energy Energy Storage System
LES	Large Eddy Simulation
LEV	Low Emission Vehicle
LFO	Lithium Iron Oxide
LFP	Lithium Iron Phosphate
Li	Lithium
Li_2MnO_3	Lithiated transition metal oxides
Li_2ZrO_3	Lithium zirconate
LIB	Lithium Ion Battery
$LiBF_4$	Lithium tetrafluoroborate
LiBOB	Lithium bis(oxalate)borate
LIBS	Laser-induced breakdown spectroscopy
LIC	Lithium ion capacitor
LIF	Laser-induced fluorescence
Li-ion	Lithium Ion

$LiPF_6$	Effective electrolyte salt for lithium-ion battery
LiPON	Lithium Phosphorous Oxynitride
LiTFSI	Lithium Bis(Trifluoromethanesulfonyl)Imide
LL	Layered lithium
LLC	Layered-layered spinel composite
LLFC	Lean lifted-flame combustion
LLNL	Lawrence Livermore National Laboratory
LMNO	Ni-substituted manganese spinel oxides
LMO	Lithium Manganese Oxide
LMR	Lithium Manganese Rich
LNT	Lean NO_x Trap
LOGIT	Logistic regression
LOMO	Lowest occupied molecular orbital
LPL	Low-pressure loop
LT	Low temperature
LTC	Low-temperature combustion
LTGC	Low Temperature Gasoline Combustion
MA3T	Market Acceptance of Advanced Automotive Technologies
MBC	Model based controls
MBSE	Model-based system engineering
MCE	Multi-cylinder engine
MD	Machine direction
MD	Medium-Duty
MECA	Manufacturers of Emission Controls Association
MECT	Mechanical electrochemical-thermal
Mg	Magnesium
MGOe	Megagauss-oersteds
MIT	Massachusetts Institute of Technology

mJ	Millijoule
MLCC	Multilayer ceramic capacitor
MLD	Molecular layer deposition
MMFC	Multi-mode flow controller
MMV	Multi-material vehicle
Mn	Manganese
Mo_2C	Molybdenum Carbide
MON	Motor octane number
MOSFET	Metal–oxide–semiconductor field-effect transistor
MOSS	Multi beam optical stress sensor
MOU	Memorandum of Understanding
MPa	Megapascal
MPG	Miles per gallon
MPGe	Miles per gallon-electric
MPG_e	Miles per gallon gasoline equivalent
MPI	Message passing interface
MS	Mass spectroscopy
ms	Milliseconds
MSU	Michigan State University
MTM	Mini-traction machine
MTU	Michigan Technological University
MY	Model year
N_2	Nitrogen
N_2O	Nitrous Oxide
NA	Naturally aspirated
Na	Sodium
NaOH	Sodium hydroxide
NBB	National Biodiesel Board

NCA	Battery cathode material (nickel cobalt aluminum oxide)
NCM	Nickel Cobalt Manganese
ND	Neutron diffraction
Nd	Neodymium
NDE	Non-Destructuve Evaluation
NERSC	National Energy Research Scientific Computing Center
NF	Nanofiber
NG	Natural gas
NGO	Non-governmental organization
NGV	Natural gas vehicle
NH_3	Ammonia
NHTSA	National Highway Traffic Safety Administration
NHV	Net heating value
Ni	Nickel
NIST	National Institute of Standards and Technology
NIST	National Institute of Standards and Technology
NMC	Nickel Manganese Cobalt oxide
NMOG	Non-methane organic gases
NMP	N-Methylpyrrolidone
NMR	Nuclear magnetic resonance
NO	Nitric Oxide
NO_2	Nitrogen Dioxide
NOx	Oxides of Nitrogen
NRE	Non-rare earth
NREL	National Renewable Energy Laboratory
NSC	NO_x Storage Catalyst
NSF	National Science Foundation
NSR	NO_x Storage Reduction

NVH	Noise, vibration, and harshness
NVO	Negative Valve Overlap
NYBEST	New York Battery and Energy Storage Technology Consortium
O_2	Oxygen
OAS	Open architecture standard
OBC	On-board charger
OBD	On-board diagnostics
OCV	Open-circuit voltage
Oe	Oersteds
OE	Department of Energy Office of Electricity Delivery and Energy Reliability
OEM	Original Equipment Manufacturer
OH	Hydroxide
ORC	Organic Rankine Cycle
ORNL	Oak Ridge National Laboratory
OSC	Oxygen storage capacity
OSU	Ohio State University
P	Phosphorous
Pa	Pascal
PAH	Polycyclic aromatic hydrocarbon
PAN	Polyacrylonitrile
PBA	Planar bond-all
PCA	Principal component analysis
PCB	Printed circuit boards
PCCI	Premixed Charge Compression Ignition
PCM	Phase change material
PCP	Peak cylinder pressures
PDT	Pulse discharge technique
PE	Power electronics

PEI	Polyetherimide
PEO	Polyethylene oxide
PEV	Plug-in electric vehicle
PFI	Port Fuel Injection
PFS	Partial fuel stratification
PGM	Platinum group metal
PHEV	Plug-in hybrid electric vehicle
PI	Principal investigator
PIV	Particle image velocimetry
PLZT	Lead lanthanum zirconate titanate
PM	Permanent magnet
PM	Particulate matter
PMI	Particulate matter index
PML	Polymer-multi-layer
PMSM	Permanent magnet synchronous motor
PN	Particulate number
PNA	Passive NOx adsorber
PNNL	Pacific Northwest National Laboratory
POD	Proper orthogonal decomposition
PPC	Partially Premixed Combustion
ppm	Part per million
PPy	Polypyrrole
Pr	Praseodymium
Pt	Platinum
PTC	Positive temperature coefficient
PVDF	Polyvinylidene difluoride
PWM	Pulse width modulation
Q&A	Questions and answers

QA	Quality assurance
QC	Quality control
R&D	Research and Development
RANS	Reynolds-Averaged Navier Strokes
RCCI	Reactivity controlled compression ignition
RCM	Rapid compression machines
RE	Rare earth
RF	Radio frequency
RFPI	Request for proposal information
RFS	Renewable Fuel Standard
Rh	Rhodium
ROI	Return on investment
RON	Research octane number
RPM	Rotations per minute
RR	Rolling resistance
RS	Rapidly solidified
RT	Room temperature
Ru	Ruthenium
S	Sulfur
SACI	Spark assisted compression ignition
SAE	Society of Automotive Engineers
Sb	Antimony
SCAQMD	South Coast Air Quality Management District
SCR	Selective catalytic reduction
SCRF	Selective catalytic reduction on filters
SDO	Standards definition organizations
SEI	Solid Electrolyte Interface
SEM	Scanning Electron Microscope

SFG	Sum frequency generation
SGIP	Smart Grid Interoperability Panel
SHA	State Highway Agency
Si	Silicon
SI	Spark ignition
SiC	Silicon carbon
SIDI	Spark-ignition direct-injection
SIMS	Secondary ion mass spectrometry
SiO_2	Silicon dioxide
SLMP	Stabilized lithium metal powder
SMD	Sauter Mean Diameter
Sn	Tin
SNL	Sandia National Laboratory
SOA	State of the art
SOC	State of Charge
SOF	Solvent extractable fraction
SS	Steady state
STEM	Scanning transmission electron microscopy
SULEV	Super Low-Emission Vehicle
SUV	Sport utility vehicle
SXAS	Soft X-ray absorption spectroscopy
TARDEC	U.S. Army Tank and Automotive Research, Development and Engineering Center
TCR	Thermochemical recuperation
TD	Transverse direction
TDC	Top dead center
TE	Thermoelectric
TEG	Thermoelectric Generator
TEM	Transmission Electron Microscope

Ti	Titanium
TIM	Thermal interface materials
TJI	Turbulent jet ignition
TM	Transition Metal
TMA	Tri Methyl Aluminum
TOF	Time of flight
TOU	Time of use
TPGME	tri-propylene glycol methyl ether
TRD	Transmission radiation detector
TR-XRD	Time-resolved X-ray diffraction
TWC	Three-Way Catalyst
TXM	Transmission x-ray microscope
U.S. DRIVE	U.S. Driving Research and Innovation for Vehicle Efficiency and Energy sustainability
UC	University of California
UConn	University of Connecticut
UHC	Unburned hydrocarbons
UM	University of Michigan
UPS	United Parcel Service
UQ	Uncertainty quantification
USABC	US Advanced Battery Consortium
USAMP	United States Automotive Materials Partnership
USCAR	U.S. Council for Automotive Research
UTS	Ultimate tensile strength
UW	UW
UWM	UW-Milwaukee
V	Vanadium
V	Volt
V2G	Vehicle-to-Grid

V2I	Vehicle-to-Infrastructure
V2V	Vehicle-to-Vehicle
V2X	Vehicle-to-Grid, Infrastructure, and/or Vehicle
VAN	Vehicle Analysis
VC	Vinylene Carbonate
VCR	Variable compression ratio
VCT	Variable camshaft timing
VIBE	Virtual Integrated Battery Environment
VM	Viscosity modifier
VMT	Vehicle miles traveled
VOC	Volatile organic compounds
VSS	Vehicle & System Simulation
VSST	Vehicle systems safety technology
VTMS	Vehicle thermal management system
VTO	Vehicle Technologies Office
VUV	Vacuum ultraviolet
VVA	Variable Valve Actuation
WBG	Wide bandgap
WFSM	Wound field synchronous motor
Wh	Watt hour
WHR	Waste Heat Recovery
WPT	Wireless Power Transfer
WSU	Washington State University
XAFS	X-ray absorption fine structure
XANES	X-ray Absorption Near Edge Spectroscopy
XAS	X-ray Absorption Spectroscopy
xEV	Electric vehicle (all configurations)
XPS	X-ray Photoelectron Spectroscopy

XRD	X-ray Diffraction (Crystallography)
XRF	X-ray Fluorescence
ZECT	Zero Emission Cargo Transport
ZEV	Zero emission vehicle
Zn	Zinc
Zr	Zirconium
ZT	Thermoelectric Figure of Merit

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11. Cross-Reference of Project Investigators, Projects, and Organizations

Cross Reference, Sorted by Project Investigator

Page Number	*Principal Investigator, Organization. Project Title (Session)*
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2-155	Ahmed, Shabbir; ANL. BatPaC Model Development (Electrochemical Energy Storage)
5-53	Ajayi, Oyelayo; ANL. Additive and Basefluid Development (Fuel and Lubricant Technologies)
1-37	Ajayi, Oyelayo; ANL. Development of High Power Density Driveline for Vehicles (Vehicle Systems)
2-209	Alamgir, Mohamed; LG Chem Power. Battery Development (Electrochemical Energy Storage)
6-56	Allison, John; U of Michigan. Phase Transformation Kinetics and Alloy Microsegregation in High Pressure Die Cast Magnesium Alloys (Light-Weight Materials)
1-45	Amar, Pascal; Volvo Trucks. A Complete Vehicle Approach to the SuperTruck Challenge (Vehicle Systems)
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3-22	Anderson, Iver; Ames. DREAM (Development of Radically Enhanced Alnico Magnets) (Electric Drive Technologies)
2-192	Arnold, John; Miltec UV International. Dramatically Improve the Safety Performance of Li Ion Battery Separators and Reduce the Manufacturing Cost using Ultraviolet Curing and High Precision Coating Technologies (Electrochemical Energy Storage)
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1-86	Smith, David; ORNL. Powertrain Controls Optimization for Heavy Duty Line Haul Trucks (Vehicle Systems)
4-139	Som, Sibendu; ANL. Advancements in Fuel Spray and Combustion Modeling with High Performance Computing Resources (Advanced Combustion)
2-118	Somorjai, G.; UC Berkeley. Analysis of Film Formation Chemistry on Silicon Anodes by Advanced In Situ and Operando Vibrational Spectroscopy (Electrochemical Energy Storage)
6-70	Song, Guang-Ling; ORNL. Corrosivity and Passivity of Metastable Mg Alloys (Light-Weight Materials)
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2-212	Stefan, Ionel; Amprius. A Commercially Scalable Process for Silicon Anode Prelithiation (Electrochemical Energy Storage)
6-21	Stephens, Elizabeth; PNNL. SPR Process Simulation, Analyses, and Development for Magnesium Joints (Light-Weight Materials)
9-12	Stephens, Tom; ANL. Impact Analysis: VTO Baseline and Scenario (BaSce) Activities (VT Analysis)
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1-34	Stutenberg, Kevin; ANL. Advanced Technology Vehicle Lab Benchmarking (L1&L2) (Vehicle Systems)
3-51	Su, Gui-Jia; ORNL. Innovative Technologies for Converters and Chargers (Electric Drive Technologies)
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2-155	ANL; Ahmed, Shabbir. BatPaC Model Development (Electrochemical Energy Storage)
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2-59	ANL; Gallagher, Kevin. PHEV and EV Battery Performance and Cost Assessment (Electrochemical Energy Storage)
4-105	ANL; Goldsborough, Scott. RCM Studies to Enable Gasoline-Relevant Low Temperature Combustion (Advanced Combustion)

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7-43	General Motors; Walker, Mike. Computational Design and Development of a New, Lightweight Cast Alloy for Advanced Cylinder Heads in High-Efficiency, Light-Duty Engines FOA 648-3a (Propulsion Materials)
3-30	General Motors; Zhao, Zilai. Next Generation Inverter (Electric Drive Technologies)
6-41	GM; Berger, Libby. Validation of Material Models for Automotive Carbon Fiber Composite Structures (Light-Weight Materials)
2-137	GM; Xiao, Xingcheng. A Combined Experimental and Modeling Approach for the Design of High Coulombic Efficiency Si Electrodes (Electrochemical Energy Storage)
1-78	Halla Visteon; Meyer, John. Advanced Climate Control and Vehicle Preconditioning (Vehicle Systems)
1-64	Houston-Galvelston Area Council; Williams, Nicholas. Zero Emission Cargo Transport Deployment Projects (Vehicle Systems)
2-140	Hydro Quebec; Zaghib, Karim. Electrode Architecture-Assembly of Battery Materials and Electrodes (Electrochemical Energy Storage)
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4-50	LLNL; Whitesides, Russell. Model Development and Analysis of Clean & Efficient Engine Combustion (Advanced Combustion)
4-164	MAHLE Powertrain LLC ; Bunce, Mike. Next-generation Ultra-Lean Burn Powertrain (Advanced Combustion)
2-31	Massachusetts Institute of Technology; Ceder, Gerbrand. First Principles Calculations of Existing and Novel Electrode Materials (Electrochemical Energy Storage)
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1-39	Navistar; Zukouski, Russ. SuperTruck - Development and Demonstration of a Fuel-Efficient Class 8 Tractor & Trailer (Vehicle Systems)
2-184	Navitas Systems; Zhang, Pu. Low-Cost, High-Capacity Lithium Ion Batteries through Modified Surface and Microstructure (Electrochemical Energy Storage)
5-41	Northwestern University; Wang, Q. Jane. A Novel Lubricant Formulation Scheme for 2% Fuel Efficiency Improvement (Fuel and Lubricant Technologies)
3-79	NREL; Bennion, Kevin. Electric Motor Thermal Management R&D (Electric Drive Technologies)
3-97	NREL; Bennion, Kevin. Power Electronics Thermal Management R&D (Electric Drive Technologies)
9-27	NREL; Brooker, Aaron. Unified Modeling, Simulation, and Market Implications: FASTSim and ADOPT (VT Analysis)
8-29	NREL; Dafoe, Wendy. Clean Cities Coordinator Resource Building and National Networking Activities (Technology Integration)

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2-182	XG Sciences; Privette, Robert. XG Sciences: Development of Silicon Graphene Composite Anode (Electrochemical Energy Storage)
6-49	Xtalic Corporation; Ruan, Shiyun. High-Strength Electroformed Nanostructured Aluminum for Lightweight Automotive Applications (Light-Weight Materials)

12. Project and Program Statistics Calculations Overview

A numerical evaluation of each project within each subprogram area and a comparison to the other projects within the subprogram area necessitates a statistical comparison of the projects utilizing specific criteria. For each project, a representative set of experts in the project's field was selected to evaluate the project based upon the criteria indicated in the Introduction. Each evaluation criterion's sample mean and variance were calculated utilizing the following formulas respectively:

$$\bar{x}_{j,k} = \frac{1}{n}\sum_{i=1}^{n} x_{i,j,k}$$

$$s^2_{\bar{x}_{j,k}} = \frac{1}{(n-1)}\sum_{i=1}^{n}\left(x_{i,j,k} - \bar{x}_{j,k}\right)^2$$

where $x_{i,j,k}$ is an individual reviewer's score for that criterion and n is the number of reviewers for the given project who answered the question[1]. The index i represents an index over the reviewers assigned for the project; the index j represents an index over the projects in that specific subprogram area; the index k represents an index over the questions asked. The sample mean for each project criterion is represented in the graph by its respective bar graph value. These calculations were performed for the numeric values supplied by the reviewers for questions 1 through 4 (those questions indicated with weight values in the Introduction).

The above values $\bar{x}_{j,k}$ and $s^2_{\bar{x}_{j,k}}$ can be used to extend the evaluation to the entire subprogram. In order to calculate the variance of each subprogram criterion, the sample variances must be propagated to the calculated variance of each subprogram criterion score. The subprogram area mean and variance for each evaluation criterion are then calculated as follows:

$$\bar{X}_k = \frac{1}{m}\sum_{j=1}^{m} \bar{x}_{j,k}$$

$$Var(\bar{X}_k) = \sigma^2_{\bar{X}_k} + \frac{1}{m^2}\sum_{j=1}^{m} s^2_{\bar{x}_{j,k}} = \frac{1}{m}\sum_{j=1}^{m}\bar{x}^2_{j,k} - (\bar{X}_k)^2 + \frac{1}{m^2}\sum_{j=1}^{m} s^2_{\bar{x}_{j,k}}$$

where m is the number of projects in a subprogram area. This method of calculation allows each project to weigh evenly on each evaluation criterion of the subprogram area. The criteria means and average of the project variances values for each subprogram area (e.g., Hybrid and Vehicle Systems Technologies, Advanced Combustion Engine Technologies, Technology Integration, etc.) are represented on each project graph as the Program Area Average bullets and the red error bar ranges, respectively, for each question. In some sense, the red error bars provide a range by which projects can be evaluated by their criteria with respect to an entire subprogram area's performance. The error bar calculation was changed from the 2011 Annual Merit Review report where the expectation of the sample error was the value calculated for the error bars. This change was made so that the error bar provides a more relevant comparison for the criteria measurements of the projects to the subprogram averages.

[1] If all of the reviewers do not answer all of the questions, the value of n will be different for some questions for a project.

Each question's score is assumed to be independent of the others for a given project (that is, for example, the question of the quality of the future research should have no bearing on the current accomplishments). Each project's weighted average score can then be calculated as follows[2]:

$$\bar{x}_j = \frac{\sum_{k=2}^{5} w_k * \bar{x}_{j,k}}{\sum_{k=2}^{5} w_k}$$

where w_k is the weight that question k has on the overall score of the j^{th} project average $\bar{x}_j$. The value above, $\bar{x}_j$, is indicated in the graphics by the Weighted Average bar. As was done for each individual project, each question's score is assumed to be independent of the others for a given subprogram. Each subprogram's weighted average score and weighted variance can then be calculated as follows:

$$\bar{X} = \frac{\sum_{k=2}^{5} w_k * \bar{X}_k}{\sum_{k=2}^{5} w_k}$$

$$Var(\bar{X}) = \frac{\sum_{k=2}^{5} w_k^2 * Var(\bar{X}_k)}{\sum_{k=2}^{5} w_k^2}$$

These values represent the Program Area Average bullet and its red error bar in the Weighted Average column.

The answers to questions 5 and 6 are represented by pie charts below the combination bar/bullet graph.

[2] There is no need to calculate a variance for this value since it is not displayed, and it has no bearing on any future calculated value in the analysis.

Appendix A: 2015 Annual Merit Review Attendees

Name	Affiliation
Douglas Aaron	University of Tennessee
Rene Abarcar	Energetics Incorporated
Tarek Abdel-Baset	FCA USA
Mohamad Abdul-Hak	Mercedes-Benz Research and Development
Tadashi Abe	The Research Association of Hydrogen Supply/ Utilization Technology
Nasim Aboualigalehdari	North Carolina A&T State Univ
Ali Abouimrane	QEERI- Qatar Foundation
Judi Abraham	Conference Management Associates, Inc.
Daniel Abraham	Argonne National Laboratory
Salvador Aceves	Lawrence Livermore National Laboratory
Makoto Adachi	Toyota Motor Corporation
Jesse Adams	U.S. Department of Energy
Danny Addison	Liox
Mahabala Adiga	Sunnyfuels LLC
Kev Adjemian	Idaho National Laboratory
Radoslav Adzic	Brookhaven National Laboratory
Kareem Afzal	PDC Machines
Alexander Agapov	W.L. Gore & Associates
Anant Agarwal	AMO/EERE/DOE
Rajesh Ahluwalia	Argonne National Laboratory
Iftikhar Ahmad	LAMBDA TECHNOLOGIES
Shabbir Ahmed	Argonne National Laboratory
Dongjoon Ahn	GS Energy
Channing Ahn	DOE/Caltech
Sang Hyun Ahn	National Institute of Standards and Technology
Christopher Ainscough	National Renewable Energy Laboratory
Oyelayo Ajayi	Argonne National Laboratory
Jonas Akesson	myFC AB
Etsuo Akiba	Kyushu University
Yoshio Akimune	Innovative Structural Materials Association
Pankaj Alaboina	North Carolina A&T State University
Boyko Aladjov	Johnson Battery Technologies, Inc.
Mohamed Alamgir	LG CHEM POWER
Fabio Albano	XALT Energy LLC
Jim Alkire	U.S. DOE
Jan Allen	US Army Research Laboratory
Jeffrey Allen	Michigan Technological University
Mark Allendorf	Sandia National Laboratories
Ibraheam Alshankiti	University of Colorado

Name	Affiliation
Charles Alsup	US DOE/NETL
Pascal Amar	Volvo Technology of America
Md Ruhul Amin	Massachusetts Institute of Technology
Rachid Amine	Argonne National Laboratory
Khalil Amine	Argonne National Laboratory
Ramin Amin-Sanayei	Arkema
Iver Anderson	Ames Lab (USDOE), Iowa State Univ.
David Anderson	U.S. Department of Energy
Michele Anderson	Office of Naval Research
Joseph Anderson	Combined Technology Solutions
Arne Andersson	Volvo GTT/TPP/ATR
Morgan Andreae	Cummins, Inc.
Michael Andrew	Johnson Controls, Inc.
Scott Ankeney	Toyota Motor Engineering & Manufacturing NA
Joel Anstrom	The Pennsylvania State University
Donald Anton	Savannah River National Laboratory
Laurent Antoni	Commissariat à l'Energie Atomique et aux Energies Alternatives
Jesse Appleton	Banner Public Affairs
Koorosh Araghi	NASA Johnson Space Center
Shane Ardo	University of California, Irvine

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John Arnold	Miltec UV
Renata Arsenault	Ford Motor Co. / USABC
David Arthur	USDOT / Volpe Center
Samuel Arthur	E.I. DuPont de Nemours & Co, Inc
Kateryna Artyushkova	University of New Mexico
Koichiro Asazawa	Daihatsu Motor Co.,LTD
Alex Askari	NAVAL SURFACE WARFARE CENTER
Plamen Atanassov	University of New Mexico, Center for Micro-Engineered Materials
Lance Atkins	Nissan Technical Center North America
Chris Atkinson	US DOE
Pradeep Attibele	Fiat Chrysler Automobiles
Stanley Autrey	Pacific Northwest National Laboratory
Michelle Avillanoza	New West Technologies, Inc.
David Avison	Madico Inc
Katherine Ayers	Proton OnSite
Susan Babinec	DOE
Chulsung Bae	Rensselaer Polytechnic Institute
Jianming Bai	NSLS-II, Brookhaven National Lab
Peng Bai	Massachusetts Institute of Technology

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Warren Baker	Naval Surface Warfare Center
David Baker	United States Army Research Laboratory
Balu Balachandran	Argonne National Laboratory
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Donald Baldwin	Hexagon Lincoln
Viktor Balema	Sigma-Aldrich Corp. LLC
Nitash Balsara	Lawrence Berkeley National Lab
Chunmei Ban	NATIONAL RENEWABLE ENERGY LAB
Jai Bansal	Argonne National Laboratory
Dan Barba	National Center for Advanced Technology
Julie Barber	ORAU
Nicholas Barbosa	National Institute of Standards and Technology
Carlos Barcena	United States Patent and Trademark Office
Ewa Bardasz	Energetics
Javier Bareno	Argonne National Laboratory
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James Barnes	U.S. Department of Energy
Brian Barnett	TIAX LLC
Bob Bartolo	Senator Bob Casey's (D-PA) Office

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Marilyn Blandford	Miltec UV International
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Ira Bloom	Argonne National Laboratory
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Bulent Chavdar	Eaton Corporation
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Luca Cho	Samsung SDI
Brian Choe	South Coast Air Quality Management District
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Ayman EL-Refaie	GE Global Research
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Mark Elvington	SRNL
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Jonah Erlebacher	Johns Hopkins University
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Michael Everett	Maxwell Technologies
Mitch Ewan	Hawaii Natural Energy Institute
Peter Faguy	U.S. Department of Energy
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Chinbay Fan	Gas Technology Institute
Jun Fang	Xiamen University
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Richard Farmer	DOE
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Umesh Gandhi	Toyota Research Inst North America
Prabhu Ganesan	University of South Carolina
Jennifer Gangi	Fuel Cell and Hydrogen Energy Association
John Gangloff	U.S. Department of Energy
Arup Gangopadhyay	Research and Advanced Engineering
Feng Gao	Ashland, Inc
Pu-Xian Gao	University of Connecticut
Tao Gao	University of Maryland
Feng Gao	PNNL
John Garbak	New West Technologies
Gabriel Garcia	Greenway Energy, LLC
Brenda Garcia-Diaz	Savannah River National Laboratory
Brian Gardner	Johnson Matthey
Nancy Garland	US Department of Energy
Jennifer Garman	Oak Ridge Associated Universities
Yannick Garsany	EXCET / NRL
John Gartner	Navigant Research
Fernando Garzon	University of New Mexico & Sandia National Laboratory
Chris Gearhart	National Renewable Energy Laboratory
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David Gelman	Sustainable Energy Strategies, Inc.
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Thomas Gennett	National Renewable Energy Laboratory
Paul George	Battelle
Jeff Gerbec	Mitsubishi Chemical
Richard Gerth	U.S. ARMY - TARDEC
Dominic Gervasio	University of Arizona
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Sujit Ghosh	U.S. MARITIME ADMINISTRATION
John Gibble	Volvo Group Truck Technologies
Jerry Gibbs	U.S. Department of Energy
Chris Gibbs	Amalyst Ltd
Vincent Giordani	Liox
Francois Girard	National Research Council Canada
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Clare Grey	University of Cambridge
Thomas Gross	Electricore, Inc.
Markus Gross	BMW Group
Stephen Grot	Ion Power Inc.
Katrina Groth	Sandia National Laboratories
Shuang Gu	University of Delaware
Zhiyong Gu	University of Massachusetts Lowell
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Cenk Gumeci	Michigan State University
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